# Planters' Record

VOL. XXVII

A quarterly paper devoted to the sugar interests of Hawaii, and issued by the Experiment Station for circulation among the plantations of the Hawaiian Sugar Planters' Association.

JANUARY TO DECEMBER

# The Hawaiian Planters' Record

VOL. XXVII.

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# THE HAWAIIAN PLANTERS' RECORD

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**Cane Varieties: An Acreage Census**

The cane variety, H109, now covers more than 52,000 acres. The Lahaina cane, formerly occupying 76,000 acres (1913 census), now holds but 13,500 acres, there being 8,500 in the 1923 crop, and about 5,000 in the 1924 crop. The 52,000 acres of H109 are divided between the two coming crops, with 23,000 acres for 1923 and 29,000 for 1924.

Yellow Caledonia shows a decrease of some 5,000 acres since last year, there being 94,000 as against 99,000 a year ago. The Yellow Caledonia area for 1923 is 49,000; the 1924 area is 45,000.

The areas of D1135, Striped Tip and Yellow Tip are substantially the same as last year. Lower areas are reported for D117, Rose Bamboo and H146.

Badila takes its place among the varieties occupying more than a thousand acres of land, and Yellow Bamboo no longer holds this distinction.

**Higher Yields per Acre**

That tropical agriculture is going to take full account of the possibilities of lowering costs of production by increasing yields per acre is plainly indicated, by "Some Notes on Rubber Estates of the Future," which we reproduce in this issue.

Individual rubber trees vary enormously in yield. By selecting and propagating the better ones through grafting, it is predicted that a very substantial increase in yield will result. With this matter of tree selection is also considered that of soil selection, which refers to choosing those areas best adapted to high yields. On these two points the average yield, it is claimed, can be more than doubled, and losses converted into substantial profits even at low prices of rubber.

**Permanent Agriculture**

The question is frequently asked: How long can Hawaiian soils hold out under intensive fertilization and extremely heavy cropping of some of our irrigated fields?

To what extent can this question be answered by the Rothamsted Experiments?

Systematic field experiments were started at Rothamsted (Harpenden, Herts, England) in 1843, and investigations have been continued for seventy-nine years. "The great object," as A. D. Hall, a former director of the work, wrote, "is to obtain knowledge that is true everywhere, and to arrive at principles of general application, leaving the farmer himself, through his more immediate advisors, to adopt these principles to his own practical conditions and translate them into pounds, shillings, and pence. Thus the farmer who visits Rothamsted must not expect to see demonstrations of the most profitable means of growing this or that crop, but rather to obtain information as to its habits and requirements which, on reflection, he can make useful under his own conditions."

Having long had the desire to discuss the Hawaiian agriculture of today with the authorities at the Rothamsted Experiment Station, we asked Mr. Muir of this Station, now in England, to represent us in interviewing Dr. E. J. Russell, the present director. We furnished the following memoranda:

A point of great interest to us, on which the Rothamsted investigations might throw some light, is whether we can have "permanent agriculture" under our intensive and continuous one-crop system of cane cultivation. Take the Waipio substation results as a basis of discussion. These fields have been under cultivation about 30 or 35 years. During this time the amount of organic refuse returned to the soil has been so little as to be negligible.

These fields were taken over by us for experimental purposes in 1912. Prior to this time they had produced about 8 tons of sugar every two years, say 60 tons of cane (cane leaves, etc., all burned, would amount to several tons more). Our experiments have been along commercial lines, that of perfecting the present intensive agriculture based on chemical fertilization and irrigation. We have gradually increased the yields to 13, 14, and 15 tons of sugar per acre. Almost every crop to date has been a little better than the last. Particularly is this true when you consider both the elements of area and time. We learn, for instance, that two years is not the optimum cropping period; that while this gives the largest yield per acre, it does not give the largest yield per-acre-per-month. On a 15½ months' crop, taken off last August, we got 10.23 tons of sugar, which is 0.66 ton-of-sugar-per-acre-per-month. This is the best to date, as the two-year equivalent would be 15.84. Ewa Plantation has reported four fields this year with yields of over 15 tons. These big yields result from:

1. Control of insect pests by parasites.
2. Suitable cane variety, having resistance to various diseases.
3. Adequate irrigation throughout the growing period.
4. Ascertaining the profitable limit of chemical nitrogen and applying it. (Also phosphoric acid and potash where field tests show it to be needed.)
5. Allowing about 10 to 12 months to elapse between the last application of nitrogenous salts and time of harvesting. (This is to improve sugar content of cane.)
6. Allowing two to three months between last irrigation and time of harvest. (This also causes sugar content to improve.)

We find it profitable to apply 300 or even 350 pounds of nitrogen to a two-year crop. Chemical examination of the soils at Ewa shows no ill effects to have resulted from heavy use of nitrate of soda year after year. If it becomes advisable to use sulphate of ammonia to offset the effects of nitrate of soda, we could do so, or we could, if necessary, turn to nitrate of ammonia.

The point is, can we continue to raise big crops for years and years from chemical fertilizers (barring increase of insects and disease, which is beside the point under discussion)? Are we depleting the organic matter of the soil and altering its water-holding capacity, or are we actually maintaining this or perhaps increasing it by producing huge root systems year after year with chemical nitrogen, these, on decaying, adding to the organic matter of the soil itself?

Rothamsted experiments tell of maintaining yield by chemical nitrogen to an extent that is equal to, if not greater than, what is done by continuous applications of barnyard manure.

With wheat and other grain crops we are told that the cost of the chemical nitrogen necessary to do this is prohibitive from a commercial standpoint. With sugar, this is not the case. Three hundred pounds of nitrogen at 20 cents per pound costs $60.00, which amounts to only $5.00 per ton on a 12-ton crop.

This being the case, is not our agriculture sound and "permanent" from the standpoint of the Rothamsted work dealing with the maintenance of yields through chemicals only?

We are in receipt of a letter from Mr. Muir, December 5, 1922, in which he tells us of the opinion expressed on this intensive sugar agriculture, considered in the light of nearly eighty years of investigations dealing with chemical fertilizers in their effects upon the soils and crops of England, those investigations including extensive comparisons between chemical and organic manures. Mr. Muir writes:

I paid a visit to Rothamsted about ten weeks ago and had a long talk with Dr. Russell. He was surprised to hear that you were using nitrate of soda without it showing any ill effect, he expected you were using nitrate of ammonia. He was also surprised that so little of the green crop had been returned to the soil on many of the plantations. But he said, after considering these points, that there was no evidence to be drawn from any of their work at Harpenden that indicated that our methods were not along the lines of permanent agriculture.

# The Java Sugar Cane Leaf-Mite in Hawaii.

By O. H. Swezey.

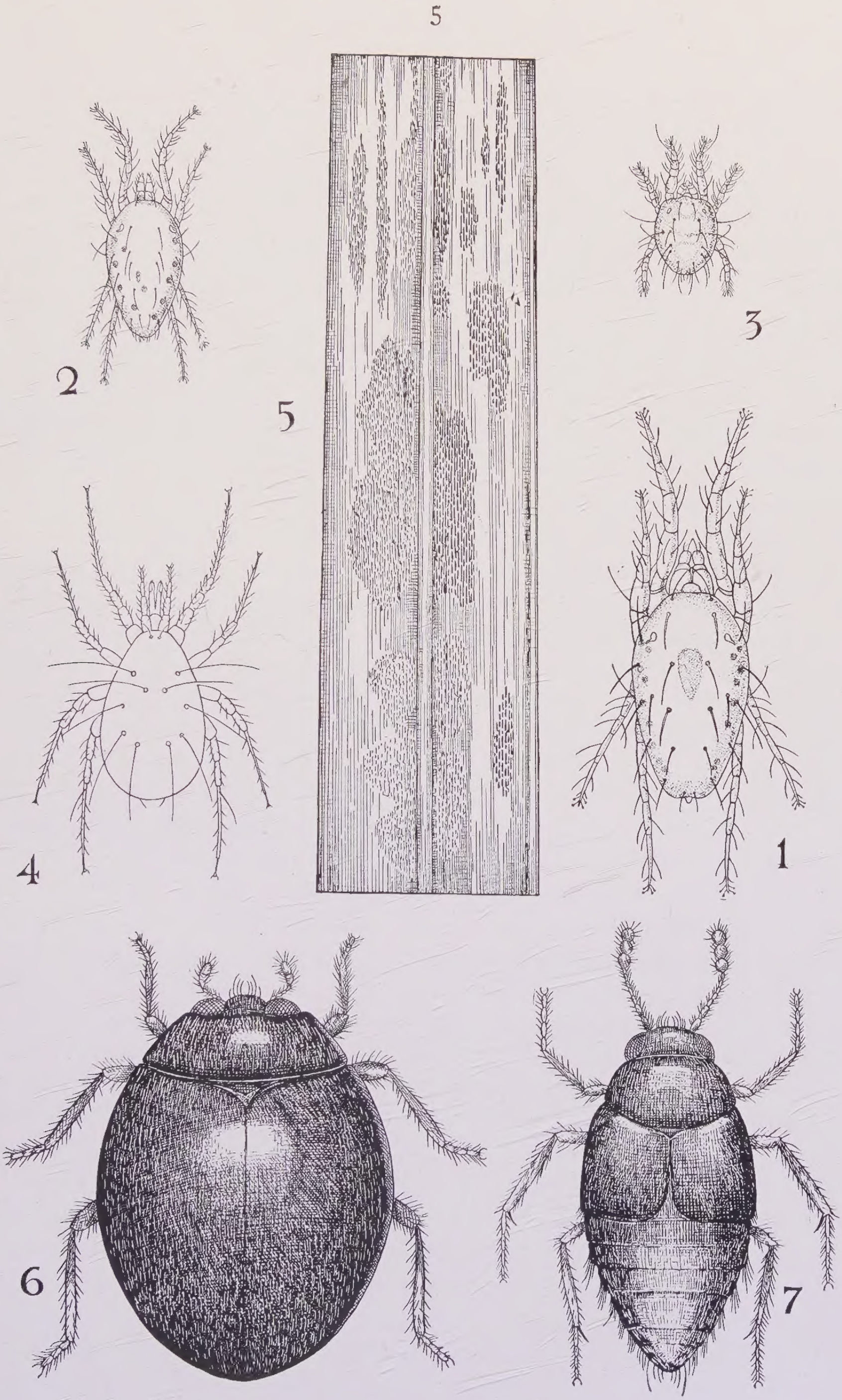
A very large infestation by the Java sugar cane leaf-mite occurred in an area of plant cane on the plantation of the Oahu Sugar Company during the summer of 1922.

The presence of this extensive infestation was first made known by Dr. L. O. Kunkel in August, when he examined conditions where the cane was not maintaining a healthy appearance. In September and October, I made several trips with him to the region, making observations on the conditions, and trying an experimental dusting to kill the mites.

The infested area included fields 43, 44, 45, 46 (partially), 47 and 49, altogether comprising about one thousand acres, being situated in the region between Kipapa Gulch and Waikakalaua Gulch, and at an elevation running from about 400 to 550 feet. It is planted chiefly to H109 cane, though there is also some D1135 and H456. The planting occurred in the various fields during April to July. The method of planting was by means of furrows opened between the old cane rows, instead of the ground having been first plowed. The previous ratoons were Lahaina, some stools of which came up between the rows of the newly-planted cane.

At the time when first noted the mites were very numerous, occurring on the underside of the lower leaves and causing them to become yellowish streaked longitudinally. Older infested leaves had become reddish in streaks; and still older ones were drying up and dying, at edges and tips first. The infestation was practically all over this one thousand acres, though in places it seemed to have passed already, evidences showing on the leaves where the mites had previously been abundant. Where the cane seemed to have been thriving on account of favorable conditions, there was apparently no special detrimental effect by the mites. In some places where on account of weeds, the condition of the ground due to method of planting, or possibly being too dry (in the hot, dry summer and perhaps not always irrigated sufficiently or frequently enough), or other less favorable conditions, the effect on the cane by the mites was more conspicuous, apparently for a time checking the growth of the cane. The cane has been improving well after some rainy weather, and the disappearance of the mites.

This leaf-mite is very small and difficult to see except with a magnifying glass, though where numerous on a leaf and viewed *en masse* their presence is readily distinguished. A heavily infested leaf may have many thousands of them in all stages of growth and eggs as well. The latter are tiny, globular, white objects placed on the under-side, usually scattered all along near the mid-rib. The mites themselves are greyish-yellow in color, with some dark spots laterally placed on the back of the abdomen, and towards the front of the abdomen are two red spots, one towards each side. They feed by puncturing the leaf and sucking out the juice, sometimes removing the chlorophyll as well, which gives a greenish color to these mites.




JAVA LEAF-MITE AND NATURAL ENEMIES.

1. Female leafmite, × 80.
2. Male leafmite, × 80.
3. Young leafmite, × 80.
4. A predacious mite, × 60.
5. Cane leaf injured by leafmites, × ½.
6. A ladybeetle (*Stethorus vagans*), × 40.
7. A Staphylinid beetle (*Oligota* sp.), × 45.

4, 6, 7. Enemies of the leafmite.

So far as I can learn this mite has not been previously recorded here in Hawaii. We have been accustomed to finding it now and then on the cane leaves in various plantations of the Islands, but never in such extensive infestations as to give attention to it, and apparently no one previously has determined it. By reference to a description and an account of its occurrence in Java, respectively in *Mededeelingen van het Proefstation Oost-Java*, n.ser. No. 37, p. 48, 1897, and *Handbook voor de Suikerriet-Cultuur en de Rietsuiker-Fabricage op Java*, pp. 282-291, Pl. 39, 1906, I am able to identify it as the same. In the first publication cited, Zehntner describes this mite under the name *Tetranychus exsiccator*. In the second publication cited, Van Deventer gives a more complete account of the mite and the insects which prey upon it. The colored plate is specially helpful in enabling one to identify the mite, as the description is rather brief.

Another species of leaf-mite, *Paratetranychus viridis*, occurs on cane leaves in Porto Rico, affecting them similarly to what the Java species does. It is only prevalent at times of drought.

At the time of the extensive infestation at Oahu Sugar Company, there were a few of the mites to be found on the cane at the Experiment Station grounds. and in fields on other plantations that happened to be visited during the time, They were conspicuously abundant in ratoon cane of field 12, Oahu Sugar Company, in a corner of the field in the shelter of the ironwood trees along the government road. Evidence of recent occurrence was also found on Lahaina cane of 1923 crop in field 52 mauka of the main infested area.

On September 29, we tried some dusting experiments on the mite in field 47, using tobacco dust, and nicodust. Examining for results on October 3, it was found that there had been little, if any, effect on the mites. There were less of them in the cane that had been treated, but in untreated cane they were also fewer in numbers. They were being preyed on by several natural enemies and seemed to be very much on the wane. When the region was visited again on October 24, the mites had almost entirely disappeared. It was very difficult to find any living mites anywhere in the whole area. This disappearance was probably due to the natural enemies, though it is difficult to say for sure, and it is impossible to account for it in any other way, though some heavy rains that occurred may have had something to do with it also.

The principal natural enemy observed in the field was a predacious mite larger than the leaf-mite and very active, which increased in abundance at the time the others were decreasing but finally disappeared itself when the leaf-mites were gone. The species of this predacious mite has not been determined.

Another enemy of the leaf-mite was a very small, black ladybeetle (*Stethorus vagans*) which commonly feeds on other species of leaf-mites usually called red spiders. Both the larvae and adults of this ladybeetle feed on the leaf-mites and each individual could eat a great number of the mites and probably their eggs also.

Still another leaf-mite enemy present was a minute Staphylinid beetle. The species is undetermined, but it may be *Oligota oviformis*, which feeds on red spiders in California. It is brown, and its larvae are whitish. Both feed on the mites and their eggs, eating great quantities of them.

It is a mystery how a pest of this kind, being wingless and able to spread only by crawling, could have become so widely spread in such a large area as one thousand acres all at the same time. There are two possibilities: If it were some pest that was on the seed cane when planted, it could be readily accounted for. But so far as we know the habits of this pest, we would not expect it to be present so generally on seed-cane, unless, perchance, it has some habit of depositing holdover eggs on or behind leafsheaths, which could have been left on the seed.

The more likely possibility is that they survived somehow from the ratoon crop previously on the field. Although the fields were burned in the usual manner for harvesting, I am told that, in some cases, it was not so thorough as could be desired. Then, due to the unusual method of planting, there was considerable growth from the old stools, and it may be that the mites or their eggs survived somehow in the old stools or in unburned trash, and that the shoots of cane from the old stools were first infested, then passing from these to the new plant.

Be that as it may, the infestation is over and finished with for the present, and whether it was specially connected with the method of planting employed may never be demonstrated; but the fact that such a large infestation (hitherto an unknown occurrence in Hawaii) occurred on this particular area makes it appear that, in some way, some phase of this procedure has favored the survival of the mites from some previous time when they must have been widely distributed though not numerous enough to be noted.

Their present sudden disappearance shows what can be expected should any such infestations occur in the future.

## Ammonium Nitrate vs. Nitrate of Soda.

Waipio Experiment L 2, 1922 Crop.

We harvested this year at Waipio an experiment in which equal amounts of nitrogen from ammonium nitrate and from nitrate of soda were compared. The cane was H109, first ratoons, 22¾ months old at harvest. The yields obtained were the same for both treatements, as shown below:

| Treatment | | | Total Pounds Nitrogen | Yield Per Acre | | |
|---|---|---|---|---|---|---|
| June 1920 | Oct. 1920 | Feb. 1921 | | Cane | Q. R. | Sugar |
| 666 lbs. N. S. | 667 lbs. N. S. | 667 lbs. N. S. | 310 | 113.3 | 8.29 | 13.67 |
| 666 lbs. N. S. | 295 lbs. A. N. | 295 lbs. A. N. | 310 | 114.4 | 8.29 | 13.80 |

Ammonium nitrate is the more hygroscopic and takes up water rather readily in damp weather. That is a disadvantage. Other factors are in its favor. It is more concentrated, requiring much less material to supply the same amount of nitrogen. One hundred pounds of nitrogen are supplied by the following weights of material:

645 pounds of nitrate of soda.
488 pounds of sulfate of ammonium.
290 pounds of ammonium nitrate.

The nitrogen in ammonium nitrate is in the form of nitrate and of ammonia. Its use, then, would accomplish the same results as are obtained from the combined use of ammonium sulfate and of nitrate of soda. On Oahu quite a bit of ammonium nitrate has been used this year as spring dressing with what seemed to be satisfactory results.

The above discussion does not include consideration of the prices of these three materials. At the present time the price of ammonium nitrate is higher than that of nitrate of soda or ammonium sulfate. This prevents it from being an important source of nitrogen at this time.

J. A. V.

# Report of the Committee on Juice Deterioration.*

By W. K. Orth.

The very few who contributed to your committee's report did so handsomely, but to make the reading at all worth while the term "juice deterioration" had to be stretched a little, taking in what might, strictly considered, belong to cane deterioration.

Records are kept at Ewa of the purities, and lately also of the quality ratios, of all cane juices (first expressed juice) according to the number of days after burning the cane is ground. Two tables were compiled to show the effect of time elapsed on the qualities of the juice. In the first are shown the averages of all juices of the first, second, third, etc., day after burning, regardless of the individual fields they came from:

PURITIES OF CANE JUICES (CRUSHER) DAYS AFTER BURNING

| DAYS— | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th |
|---|---|---|---|---|---|---|---|---|
| January ...... | 85.6 | 85.0 | 84.7 | 84.3 | 84.2 | 84.6 | 83.4 | 83.4 |
| February ..... | 84.9 | 85.9 | 85.1 | 84.7 | 83.1 | 82.6 | 81.5 | 81.4 |
| March ........ | 87.4 | 87.3 | 85.8 | 84.9 | 84.4 | 84.5 | 82.1 | 80.7 |
| April ......... | 85.8 | 88.8 | 88.6 | 88.7 | 86.8 | ... | ... | ... |
| May ......... | 88.8 | 88.0 | 87.6 | 87.5 | 86.7 | ... | ... | ... |
| June ......... | 88.0 | 86.9 | 86.6 | 86.2 | 85.3 | 84.8 | ... | ... |
| July ......... | 86.2 | 85.3 | 84.0 | 85.1 | 84.4 | 85.1 | 83.9 | ... |
| Average ..... | 86.66 | 86.99 | 86.36 | 85.80 | 84.28 | 84.08 | 82.50 | 80.70 |
| Drop in Purity. | ... | .33 | —.30 | —.86 | —2.38 | —2.58 | —4.16 | —5.96 |
| No. of Samples. | 152 | 181 | 209 | 177 | 136 | 66 | 48 | 16 |

*Presented at the First Annual Meeting of the Association of Hawaiian Sugar Technologists, Honolulu, November 15-18, 1922.

A second table shows the drop in purities and the change in the quality ratios from the first day after burning to the second, third and following days, for juices from individual fields:

| Days After Burning. | Purity Drop. | Q. R. Change. | No. of Fields Sampled. |
|---|---|---|---|
| 2 | .5 | +0.2 | 18 |
| 3 | 1.3 | +0.2 | 18 |
| 4 | 1.3 | +0.25 | 15 |
| 5 | 1.9 | +0.4 | 12 |
| 6 | 2.3 | +0.1 | 12 |
| 7 | 2.5 | +0.3 | 8 |
| 8 | 2.5 | +0.3 | 2 |
| 10 | 4.8 | +0.6 | 3 |

These figures do not require much comment; nothing new is shown, but the wide range of the data should make them valuable. They again point to the necessity of having burnt cane through the mill as soon as possible.

A breakdown stopped the mill at Ewa for four days, with cane that had passed the first set of knives on the carrier, the yard well filled with cane on cars and a cut supply in the fields. When grinding again, the juice from the cane on the carrier had spoiled so much that it could not be clarified for analysis. The cane on the cars had apparently kept better than the cane in the field. The last juice of a certain field ground on the day of the breakdown had 85.5 purity; the cane on the cars during the first day of grinding again 85.0; and the cane in the field 83.6. The latter was then perhaps one-half to one day older than the cane on the cars.

## MILL JUICES

**Crusher Juice:** Three tests of five hours' duration did not show any deterioration during the first three and only a very slight drop in purity at the end of the fifth hour. The initial purities ranged from 81.2 to 78.8 and after five hours from 81.2 to 78.2. No preservatives were used.

**Last Mill Juice:** Five tests on the last mill juice of Brix about 2.5 showed an average drop in purity during the first half hour of 1.9, at the end of the first hour 5.0, and at the end of the fifth hour 7.2, when no preservative was employed. With four drops of formalin per gallon, the figures were 0.5, 0.7, 3.7 respectively, indicating the necessity of a preservative and of frequent sampling of last mill juices.

**Mixed Juice:** Mr. H. Walker of Pioneer Mill Company writes:

Samples of mixed juice from the mill tank, kept in the laboratory in covered buckets, ordinarily lost from 0 to 0.2 polarization reading (dry lead method) in one hour. Samples of the first juice entering the scale tank on starting up the mill, after several

hours' shut down, lost from 0.2 to 0.5 in reading during the first hour and deteriorated a little more rapidly on standing longer. When the mill was washed down thoroughly and the mixed juice line flushed out with water just before starting up, the first runnings showed less tendency to deteriorate.

In order to get an idea of the effect of lack of cleanliness on the keeping qualities of juice, a five liter sample of mixed juice was divided into two portions, to one of which was added 25 cc of an actively fermented juice about 24 hours old. Both samples were allowed to stand in covered buckets in the laboratory and polarized at intervals. "A" is the untreated, and "B" the inoculated juice.

| | At Once. | 20 Min. | 1 Hr. | 4 Hrs. | 8 Hrs. | 18 Hrs. | 22 Hrs. |
|---|---|---|---|---|---|---|---|
| "A" Reading ........ | 60.8 | 60.8 | 60.7 | 60.6 | 59.5 | 49.1 | 36.5 |
| Percentage Lost on Original Reading ... | 0 | 0 | 0.16 | 0.33 | 2.1 | 19.2 | 40.0 |
| "B" Reading ........ | 60.5 | 60.4 | 60.35 | 59.75 | 57.9 | 27.7 | 11.2 |
| Percentage Lost on Original Reading ... | 0 | 0.16 | 0.25 | 1.0 | 4.3 | 54.2 | 81.5 |

While the inoculated juice went off about twice as fast as the other, very little change took place in either during the first hour. After 22 hours "A" contained 1.05%, "B" 1.20% glucose, an indication that glucose was used up as fast as formed.

The average time in transit from crusher to juice heaters is less than fifteen minutes. This is too short an interval for any appreciable deterioration, even in badly infected juice. Trash and juice allowed to accumulate around the mill may suffer an almost total loss of sucrose, but the proportion so lost of the total sucrose passing through the mill in very small.

For the same purpose, to trace the influence of cleanliness or the lack of it on the keeping qualities of juices, similar experiments to Walker's happened to be made at Ewa.

One portion of the juice samples, five gallons to start with, were infected with a small handful of cush-cush that had collected below the third mill rollers and was strongly sour—"B". The other portion was not so treated—"A".

| | At Once. | 30 Min. | 1 Hr. | 1½ Hrs. | 2 Hrs. | 2½ Hrs. | 3½ Hrs. | 4 Hrs. |
|---|---|---|---|---|---|---|---|---|
| Purity of "A".. | 80.42 | 80.42 | 80.52 | 80.52 | 80.32 | 80.22 | 79.90 | 79.75 |
| Drop in Purity.. | .... | .... | * .10 | * .10 | .10 | .20 | .52 | .67 |
| Purity of "B".. | 80.42 | 80.42 | 79.72 | 79.42 | 79.12 | 78.72 | 78.35 | 73.75 |
| Drop in Purity.. | .... | .... | .70 | 1.00 | 1.30 | 1.70 | 2.07 | 6.67 |

* Increase in purity.

In our case also, glucose did not increase but remained for four hours at 1.45%.

To test the possible argument that a destruction of sucrose might not be shown by figures based on polarization, on account of glucose being at first more actively fermented by zymase then the sucrose is inverted by invertase, a number of Clerget sucrose determinations were run which indicated that this is not the case and the results of the experiments seem indeed to show that no great deterioration takes place during the time the juice is in transit to the heaters.

However, this does not change our conviction that the greatest cleanliness around the mills is essential for highest recovery. The effect of the infection by fermented juice or sour cush-cush may not be strong enough to destroy sucrose in the inoculated juice during the short time of half an hour, yet the quantity of badly deteriorated material accumulating on the old apron conveyors and in the crevices and corners of some mills, which material from time to time is washed into the juice, is enough to lower appreciably the purity of the mixed juice below that what it should be. This we shall try to demonstrate by figures taken from records at Ewa.

The average differences between crusher juice and mixed juice purities for thirty-two weeks, taken from 1921 and 1922, records were:

| | |
|---|---|
| First samples taken on Mondays | 3.09 |
| Average for Mondays | 3.23 |
| Mondays, after Sunday cleaning | 3.60 |
| Tuesdays | 4.00 |

During fifteen weeks' grinding, with nine roller mill, with reduced chance of souring, the differences were:

| | |
|---|---|
| Mondays | 2.75 |
| Tuesdays | 2.75 |

But during twenty weeks following grinding with eighteen rolls:

| | |
|---|---|
| Mondays | 4.16 |
| Tuesdays | 4.53 |

This showing caused us to wash down the mill whenever we had a chance to do so and on quite a number of days we stopped the mill purposely to clean it with hot water. On such days the crusher-mixed juice difference was 2.07. On other days it was 3.07, which was the average of twenty-five samples.

We realize that at Ewa conditions have been severer than in many other places. The protracted grinding seasons of late years have prevented bringing the mills fully up to date in regard to cleanliness. That a step has been made in the right direction, by the installation of two Meinecke conveyors and steep sided more self-cleaning juice trays, is shown, to our mind, by the lessening of the crusher-mixed juice differences since part of our mill was thus equipped during the past season. While previously the difference was 4.78 (1921), 4.28 (1920), 3.65 (1919), it is now 2.80 with the same eighteen roller mill and about equal extraction.

With regard to preservation of mixed juice by means of either formalin, soda ash, or mercuric chloride, Mr. V. P. Iyer of Paauilo furnishes us with the results of a great number of carefully conducted experiments. The outcome is that formalin proved the most reliable, and soda ash, in combination or without lime, the least satisfactory.

## HOT JUICES

Mr. Iyer made the experiments on a suggestion given us by Mr. N. King of Koloa, who found that soda ash proved in his case the cheapest and most effective preservative for hot juice kept over night in settling tanks. Mr. King gives the results of a test as follows:

| Treatment. | Brix | Pol. | Purity | After 14 Hours. Brix | Pol. | Purity | Drop |
|---|---|---|---|---|---|---|---|
| Heavy liming and formalin | 9.6 | 7.45 | 77.6 | 10.2 | 7.79 | 76.4 | 1.2 |
| Heavy liming alone | 10.9 | 9.17 | 77.1 | 11.9 | 8.97 | 75.4 | 1.7 |
| Heavy liming and soda ash, 1¾ lbs. per tank | 10.4 | 8.10 | 77.9 | 10.5 | 8.17 | 77.8 | 0.1 |

Mr. King continues: "Since the first of April we have been using soda ash in that capacity and find it highly satisfactory."

At Ewa we made experiments on the same lines with these results:

| TREATMENT | TEMPERATURE | PURITY | DROP |
|---|---|---|---|
| *Juice in settlers for 28 hours.* | | | |
| Limed neutral to litmus + 10 lbs. soda ash for 7000 gallons | In 212° F. | 82.3 | |
| Same | Out 161° F. | 81.9 | 0.4 |
| Limed neutral to litmus + formalin 1 part in 3500 | In 212° F. | 83.2 | |
| Same | Out 161° F. | 82.7 | 0.5 |
| Limed neutral to litmus + 1 bucket of lime in 7000 gallons | In 212° F. | 85.2 | |
| Same | Out 161° F. | 83.1 | 2.1 |
| *Juice in settlers for 26 hours.* | | | |
| Over-limed + formalin 1 part in 7000 | In 212° F. | 82.0 | |
| Same | Out 160° F. | 80.5 | 1.5 |
| Limed neutral to litmus + extra bucket of lime | In 212° F. | 84.6 | |
| Same | Out 169° F. | 82.5 | 2.1 |
| Limed neutral to litmus + 10 lbs. soda ash per 7000 gallons | In 212° F. | 83.4 | |
| Same | Out 165° F. | 81.3 | 2.1 |
| *Juice in settlers for 25 hours.* | | | |
| Over-limed | In 185° F. | 82.3 | |
| Same | Out 160° F. | 80.4 | 1.9 |

Mr. Walker reports the following under "Hot Juices":

Frequent stoppage for lack of cane in 1921 gave us an opportunity to check up on deterioration in the settling tanks. Following is an average of 207 analyses representing 207 tanks held on the average 11.903 hours per tank:

| IN | | | OUT | | |
|---|---|---|---|---|---|
| Brix | Pol. | Purity | Brix | Pol. | Purity |
| 14.42 | 12.02 | 83.32 | 14.44 | 11.98 | 83.01 |

Loss in Purity 0.313.

We still follow the system outlined several years ago of heating only to 180° F. that juice which is to be held in the settling tanks for more than an hour or so. When running steadily we average about 200° F. in the settling tanks, as a much lower temperature seems to retard settling.

Carpenter and Bomonti (*Hawaiian Planters' Record,* 1921, XXV, page 171) say that "The experiments of H. S. Walker and A. Fries cited in the 1920 report of the committee on juice deterioration indicate that bacteria are active in hot juices." As a matter of fact none of my experiments indicated such a condition. On the contrary they showed that at temperatures above 170° F. the rate of decomposition of cane juice increased rapidly with the temperature and that such deterioration was brought about by heat, not by bacterial action. The experiments of Carpenter and Bomonti although covering a different temperature range (122° to 176° F.) and demonstrating the effect of heat resisting bacteria, also showed a marked deterioration, even in sterile juice, increasing with the temperature. The large loss in purity they obtained with sterilized and unsterilized juices at 176° F. does not accord with ordinary factory practice and would suggest something abnormal in the juice they used.

The old researches of Herzfeld on the decomposition of very slightly alkaline sucrose solutions although not necessarily applicable to factory conditions, are worth remembering in this connection. The amount of sucrose decomposed per cent on that originally present or, very roughly, the drop in purity, per hour in a ten per cent sugar solution was at

| | |
|---|---|
| 176° F. | .0444 |
| 194° F. | .0790 |
| 212° F. | .1140 |

The loss at the boiling point was about two and one-half times as great as at 176°. Taking 176° F. as the average temperature of juice held over at Pioneer, we would expect then a loss in sucrose in 12 hours of 0.53% of the total. Our actual average loss in purity on 207 samples was, as reported above, 0.31%.

During the 1921 season we made three laboratory tests on the deterioration of juice by heat resisting organisms. A bucket of hot juice from the settling tanks was poured into a number of 200 cc bottles and allowed to stand at laboratory temperature. The bottles were rinsed out with boiling water and drained just before filling, then plugged with absorbent cotton. The polariscope reading of different bottles of clarified juice from time to time was as follows:

| | | | | | | |
|---|---|---|---|---|---|---|
| Hours | 0 | 15 | 24 | 38 | 64 | 115 |
| Reading | 34.0 | 34.0 | 33.1 | 33.0 | 32.9 | 32.4 |
| Loss % total | 0 | 0 | 2.6 | 2.9 | 3.2 | 4.7 |

The deterioration was slow and irregular. It had been expected that once started, decomposition would go on with increasing speed as in the case of raw juice. The experiment was stopped on account of running out of samples, though the last one polarized was not visibly "sour."

A similar test, made on the limed and heated juice entering the settling tanks, ran as follows.

| | | | | | |
|---|---|---|---|---|---|
| Hours | 0 | 24 | 48 | 72 | 96 |
| Reading | 45.0 | 44.7 | 44.3 | 41.9 | "Sour" |
| Loss % total | 0 | 0.67 | 1.6 | 6.9 | |

This juice spoiled much quicker than the clarified juice. The sample kept 96 hours had changed in color to a light yellow and was too sour to clarify with lead subacetate. Apparently the mud, which had not been removed as in the first experiment, had a bad effect on the keeping qualities of the juice. To test this another experiment was run on clarified juice:

| | | | | | |
|---|---|---|---|---|---|
| Hours | 0 | 25 | 33 | 48 | 57 |
| Reading | 45.9 | 45.75 | 45.60 | 45.45 | 44.0 |
| Loss % total | 0 | 0.33 | 0.65 | 0.98 | 4.1 |

Deterioration was slower at the start, but after 57 hours was worse than in either of the other tests. The last sample was sour and the reading doubtful as it was hard to get a clear filtrate.

These experiments may indicate the action of heat resisting bacteria such as found by Carpenter and Bomonti or of other organisms whose spores withstood a temperature of 200° F. Accidental infection after hot juice had been taken from the settling tanks may also have been possible. In the second experiment the temperature of the juice at the time of filling the bottles had dropped to 138° F. It might be worth while repeating these experiments under better bacteriological control than obtains in a sugar factory laboratory.

Deterioration of juice held over in settling tanks may be caused by bacterial action, by the effect of heat, or by both these agencies together. From 212° F. down to about 160° F., decomposition is brought about by heat, and is much less at the lower temperatures. Below 160° thermophilic bacteria may function, producing an acid which inverts sucrose. Losses may be minimized by liming juice which is to be stored to a decided phenolphthalein alkalinity, heating only to a temperature high enough to prevent cooling below 160° during storage and storing in well insulated and covered tanks. It is possible that re-infection of partially cooled juice in uncovered tanks may do more damage than the bacteria originally present.

To be independent of the few Saturday night shut-downs at Ewa, we planned some thermos bottle experiments to test the different preservatives and the effect of heat at the same time. Quart thermos bottles were used. The time of incubation in Experiment I was 28½ hours.

EXPERIMENT I.

| | Treatment | Purity |
|---|---|---|
| | Mixed juice check | 79.2 |
| A. | Slightly alkaline to litmus, in 212° F., out 144° F. | 77.2 |
| B. | As "A" + formalin 1 part in 3800, in 212° F., out 144° F. | 77.2 |
| C. | As "A" + 1 gm. $Na_2CO_3$ in 1 qt. of juice, in 212° F., out 152° F | 77.2 |
| D. | As "A", in 185° F., out 140° F. | 77.2 |
| E. | As "B", in 185° F., out 140° F. | 77.2 |
| F. | As "C", in 185° F., out 138° F. | 77.2 |

There was no appreciable effect due to variations in temperature or preservatives.

Two portions of mixed juice, "A" and "B", were limed to barely blue on red litmus paper, in the second experiment.

EXPERIMENT II.

| Temperature | Purity | Drop after 2½ Hrs. |
|---|---|---|
| A. In 180° F. | 80.1 | |
| Out 171° F. | 79.8 | 0.3 |
| B. In 212° F. | 80.65 | |
| Out 190° F. | 80.1 | 0.55 |

If heat is responsible for the difference in purity drop, the increase with higher temperature is somewhat in the proportion given by Herzfeld. (See Walker's letter.)

Experiment III was mixed juice limed slightly alkaline to litmus when cold. (no preservative).

EXPERIMENT III.

| Temperature | Purity | Drop after 4¾ Hrs. |
|---|---|---|
| A. In 180° F. | 77.8 | |
| Out 163° F. | 77.15 | 0.65 |
| B. In 212° F. | 77.65 | |
| Out 192° F. | 78.2 | +0.55 |

To test the effect of heavy liming and heat, mixed juice was limed distinctly alkaline to phenolphthalein when cold, in Experiment IV.

EXPERIMENT IV.

| Temperature | Purity | Drop after 3½ Hrs. |
|---|---|---|
| A. In 180° F. | 77.3 | |
| Out 172° F. | 77.15 | 0.15 |
| B. In 212° F. | 77.70 | |
| Out 190° F. | 78.10 | +0.40 |

In Experiments III and IV, an increase in purity with the higher temperature and heavier liming may be due to the destruction of glucose.

Experiment V was mixed juice slightly over-limed to litmus.

EXPERIMENT V.

| Temperature | Purity | Drop after 3½ Hrs. |
|---|---|---|
| A. In 180° F. | 78.9 | |
| Out 167° F. | 78.5 | 0.4 |
| B. In 212° F. | 79.1 | |
| Out 191° F. | 79.1 | 0.0 |

A few tank experiments were carried out with mixed juice heavily limed without the use of preservative, and the following results were obtained:

| | Temperature | Purity | Drop after 28 Hrs. |
|---|---|---|---|
| A. | In 185° F. | 83.3 | |
| | Out 148° F. | 80.6 | 2.7 |
| B. | In 184° F. | 82.3 | |
| | Out 159° F. | 79.7 | 2.6 |
| C. | In 185° F. | 82.3 | |
| | Out 162° F. | 81.1 | 1.2 |

Mixed juice, limed neutral to litmus plus formalin one part in 5000, was put in at 180° F. and taken out at 148° F. The purity of the juice at the beginning was 81.5 and after twenty-eight hours, it was 74.6, showing a drop of 6.9.

At Ewa we heat the juice to be kept in tanks to 212° F. in order to be sure that the temperature does not sink below 160° F. As preservatives, we over-lime and add formalin, one part in 3000. It appears to us that in our case it is more important to prevent the juice from cooling below 160° F. than to try avoiding the effect of the higher heat on sucrose.

## PRESS CAKE

It seems reasonable to expect that, if deterioration has started in the mud-presses, the polarization of the discharged mud should continue to go back during the first hour or so. A number of tests made at Ewa showed no drop in polarization during the first two hours. The polarizations of the cake used in the experiments ranged from 4.3 to 1.0. Apparently then no appreciable deterioration in mud-presses needs to be feared if no large storage tanks are used, if the settlings are kept hot and alkaline, and only the hottest water available is used for sweetening off. These are the precautions that were taken during the experiments. If sweetening off is unduly prolonged it may be advisable to keep the water also alkaline. We did notice that when water was kept in longer than three hours it had a tendency to run acid. Extremely low polarization of the mud is in such cases most probably due to inversion.

## SYRUP AND MASSECUITES

It is generally accepted that deterioration in the sense of destruction of sucrose does not take place in these products under ordinary circumstances, if they are not allowed to become distinctly acid. If the difference between gravity purity and apparent purity in mixed juice and the syrup coming from it is an indicator, a slight destruction of glucose is shown in our case, where the difference is for mixed juice 1.02 and for syrup 0.89.

Tests made at Ewa show that no deterioration went on in the crystallizers. Glucose: Polarization ratios, established for seven crystallizers from day to day at different times of the season, remained without change for as long as fourteen days. A few short runs on massecuites stored in tanks, however, gave us reason to suspect deterioration there.

Mr. G. F. Murray of Hamakua Mill sent us these notes:

Replying to your favor of recent date asking for data on Juice Deterioration, would say that I have nothing original to contribute.

In ordinary week-day practice, I find that by heating the juice to 210°-212° F., and liming to distinct alkalinity to litmus, I get the best results. Any material deviation from this invariably results in poor clarification, and underliming, that is, liming to neutrality or slight acidity to litmus, results in a decidedly acid juice and this in turn to a decided loss in sucrose.

A clasification test, conducted by Mr. McAllep, while on a visit to this mill, might be of interest. The test started at 10:30 a. m. on June 15, 1922, and lasted one hour and thirty minutes. The stations concerned were run on the usual schedule. Mixed juice, clarified juice, resettled juice, mud press juice, and syrup samples were composited in proper sequence in order to get, as nearly as possible, the same juice throughout. The results of this test were as follows:

| Juice | Temperature | Purity |
|---|---|---|
| Mixed | | 86.00 |
| Clarified | 206°-208° F. | 87.26 |
| Resettled | 180°-190° F. | 85.7 |
| Mud Press | 210°-212° F. | 84.4 |
| Syrup | | 86.6 |

The apparent drop in purity of resettled juice and mud press juice is accounted for by the addition of lime at the resettling tanks. This lime raises the brix of the juice, thus lowering the purity. There was no evidence of destruction of sucrose as the juices in question were distinctly alkaline and up to proper temperature.

After the mill shuts down Saturday evening the juice left over in the clarifiers is further limed at the rate of 5 gallons of milk of lime per 1000 gallons of juice. No other preservative is used, as I find there is no loss in purity if the juice is not kept longer than 24 hours.

I add a half gallon of formalin to each tank of syrup in order to sterilize the foam and sides of the tank.

This is all we have to offer from Association members. The report may close with the only article pertaining to the subject which I was able to find among the last two years' publications. In the Java *Archief* of 1921 G. Loos and A. Schweizer write:

Last year the authors drew attention to the rapid diminution of the polarization of bagasse on keeping. On further examining this phenomenon, it was ascertained that if the sample is so chopped that the outer layers of the cane are very finely divided, the polarization falls from 3—0% in about seven hours, whereas if the rind remains more or less intact, and therefore mostly only the pith passes through the sieve, the deterioration is much less rapid. Presumably this action is due to an enzyme or other agent present in the rind of cane.

It is not very difficult to believe that when the last mill juices are used for maceration they should deteriorate at least as quickly as the bagasse juice, seeing that they are distributed over such a large surface of crushed cane. A study of the control figures of Modjokerto factory, Java, relating the purity of the first and last mill juices appears to prove this. Thus the differences in the purity of the first and last mill juices in the case of a plant having a crusher and four mills, and macerating with water alone was 5.0 with one factory and 7.7 with another; but was 11.1; 13.0 and 14.8 in the case of three others using the last mill for their maceration; and 8.1 when water was used during the first half and last mill juice during the second half of the campaign.

# The Importance of Seedling Propagation As Illustrated By H109*.

By W. P. Alexander.

If one were to analyze the problem of cane improvement as it affects a specific plantation, he would have to answer the following questions:

Am I growing the varieties of cane that are best suited to my local conditions in general?

Have I determined the specific variety adapted to each section or different fields on the plantation, i. e., have I a different cane for my lowland, my uplands, poorly drained fields and ideally located fields?

Could I replace, if necessary, any of my varieties with a good substitute, i. e., am I prepared for the eventual failing of my standard varieties?

Provided one is able to answer these three questions in the affirmative, then I believe he is ready to ask:

Have I the superior strains of my varieties?

Is it not possible to isolate a better strain?

Can I eliminate the poorer strains of the varieties?

Will not continual selection of my planting material insure the permanency of my variety and prevent its decline?

The propagation and selection of seedling canes is a proved proposition in the Hawaiian Islands, as elsewhere in the world. The results obtained have been above expectations. A variety of cane has been produced which is resistent to the root-rot known as the Lahaina disease. It is now grown on over 50,000 acres. This has all been accomplished in a period of ten years.

I will sketch the history of the development of this cane briefly, a variety whose worth in money to the sugar planters has been placed at millions of dollars.

In December, 1905, the first large sowing of seed from the tassels was made by the Experiment Station of the Hawaiian Sugar Planters' Association, of which C. F. Eckart was the director of the Division of Agriculture. H109 was one seedling out of the 5232 which were propagated in 1905-1906. It came from a Lahaina tassel. Whether it was self-fertilized or fertilized by stray pollen of another variety is not known.

The nursery work connected with propagation of cane seedlings is not very difficult. It requires a knack and intuitive skill to be able to get the seedlings in the ground. This I have found to be the case from personal experience.

The real task presents itself in the proper selection of the new canes. It is a matter of elimination of the undesirable. How this was done in the first

* Read at the first annual meeting of the Association of Sugar Technologists of Hawaii; Honolulu, November 15-18, 1922.

H. S. P. A. propagation is shown below*:

| Year. | Canes Grown. | Number Eliminated. | % Discarded on 1st Planting. |
|---|---|---|---|
| 1906 .......................... | 5232 | .... | ..... |
| 1907 .......................... | 1159 | 4073 | 77.84 |
| 1908 .......................... | 802 | 357 | 6.83 |
| 1909 .......................... | 349 | 453 | 8.66 |

No big attempt during this period was made to raise more seedlings, as all effort was concentrated in discarding the poorest and retaining the best. After three years 6.67 per cent were retained and among them was H109.

The pioneers in this seedling propagation were well repaid for their painstaking work in getting these new varieties ready for the actual growing conditions of the plantations. They followed the policy laid down in 1906,† namely:

To distribute no cuttings of Hawaiian seedlings until about three and one-half years had elapsed since seed was sown, for the reason that it would not be possible during a period of less than that time.

To select seedlings according to field characters.

To test and select seedlings with respect to juice analysis, etc.

To estimate cropping value of the plants by plot tests.

To grow sufficient seed cane from seedlings for distribution among plantations.

In 1908, thirty-one seedlings, including H109, were considered worthy of studying under plot conditions. In the test, harvested early in 1911 at Makiki, H109 ranked eighth for twenty-month-old canes, and in 1912 a short ratoon test, H109 ranked fifth.

The results from the first shipments of H109, sent to the plantations in 1909, began to be heard from in 1912. In most cases the few lines of cane planted from the original seed material from the Station was cut for seed as soon as possible and planted out again. At that, the areas were very small. Very encouraging reports concerning H109 came from Aiea, Waimanalo, Kilauea, McBryde, and Ewa.

At the first named place, Honolulu Plantation, the yield in a single line test was 114 tons of cane per acre as against 86 tons per acre for the Lahaina check line.

Except for Ewa, none of these five plantations, where preliminary tests were so favorable, continued at that time to spread H109. It remained for George F. Renton Sr., Manager of Ewa Plantation Company "to put H109 on the map". His strong convictions are reflected as early as 1909 in the report of the Committee on Cultivation, Irrigation, and Fertilization of that year. He said:

The raising of Hawaiian seedlings and other varieties of previously imported canes on every plantation, so as to enable us by thorough test to compare them with our standard Lahaina, is something the importance of which cannot be overestimated. It is now being done by all of us. What it is wished to emphasize in this brief allusion to this subject is the importance of growing a sufficient quantity of, and of testing, the most prom-

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*Exp. Sta. Report, 1917.

†Exp. Sta. Report, 1906.

ising of these varieties on fairly large areas, in various locations on each plantation. The reason for this is that not always can sufficiently definite results be obtained on a small experimental plot, which merely indicates the preeminence of certain varieties on that particular location or plot. As a matter of fact, a number of plantations contain several different soils within their boundaries, and, unless experiment stations are conducted on each of these different soils, results are apt to be misleading. * * * * * Hitherto all the irrigated places have pinned their faith principally to Lahaina. It is a splendid cane, with magnificient ratooning qualities. Perhaps, however, the time may come when diseases or insect enemies may sap its strength. And if this should happen, it would be well for us to be prepared to substitute another variety or other varieties which have been found by test to be suitable, and from these fairly good-sized areas before referred to, obtain sufficient seed canes with which to effect the change in the shortest space of time. It is an old saying that ''sugar is made in the field''. Certain it is that the condition of our fields is of prime importance.

It was by applying definitely in practice these ideas that he was able to select H109 from many other canes and demonstrate that for his conditions H109 was the cane he was looking for.

H109, by 1913, was being tried out on five sections of Ewa Plantation, each with a different soil condition to contend with. Along with H109 was being tested practically every variety and seedling in existence in the Islands. The areas planted to each variety were not very small. The yields from H109 led them all.

Enough seed was accumulated in 1911 to plant over one-half an acre. It was planted with other varieties in Field 13-C, where conditions were not of the best. To shine here, a cane had to be A No. 1. The yield obtained was excellent, 81.19 tons of cane per acre as against 67.92 for an average of Lahaina and other varieties. This was in spite of the fact that seed was obtained from this plot to plant a larger area.

In 1912 Field 20-C, an area of 25.2 acres, was planted solid to H109. Lahaina had failed badly here, but H109 grew well. It yielded as high as 78.38 tons of cane per acre, and 10.45 tons of sugar, with a quality ratio of 7.5. This crop gave 90 tons of cane per acre from the fourth ratoons.

There was now no longer any question in the mind of Mr. Renton that H 109 was the cane to meet Ewa's conditions. All his patient, persistent work in experimenting had been rewarded. He planted 281 acres to H109 that year. It required courage to extend this new variety so rapidly, for others had not yet been convinced that here was the cane to solve the Lahaina disease problem, a truly resistant variety that was as good, if not better, than Lahaina.

Ewa Plantation had planted 2500 acres by the end of 1916 before its example was really followed on a large scale by the other plantations. Since then almost all plantings on all irrigated lowlands in the Islands have been confined to H109. This is a sure tribute to George F. Renton Sr. Within three years from the time he received the first H. S. P. A. Experiment Station seedlings he led the way in selecting and planting on a plantation scale the one cane that now leads the world in tons of sugar produced per acre on 288 acres.

The success of this seedling cane, H109, is so real and personal to everyone situated on an irrigated plantation, that it should fire the imagination of all those in the industry. It should make us feel "that no stone should be left unturned"

until a variety has been found that will be adapted to each and every condition of cane culture which we have to deal with in the Islands. We hear rumors that Yellow Caledonia, grown on 100,000 acres, about half the total area on plantations, has seen its best day, and is on its decline. Are we prepared to put in the place of Yellow Caledonia a cane that is equal to it or better? If so, I have not heard of it. The Tip canes are ideal for many locations and yet cannot grow there profitably on account of Yellow Stripe disease. Is there a cane that will equal undiseased Tip canes on mauka fields?

Take our thoroughbred cane, H109, that responds so to ideal conditions, it has its weaknesses, being very susceptible to leafhopper attacks and the leaf disease, Eye Spot, and also to a terrible foreign disease in Fiji. Are we in a position to substitute for H109 that cane which would be resistant to this dreaded stranger, the Fiji disease, should it accidentally come here?

We are not yet in a position where the propagation of seedling canes and their selection in the field can stop. We never shall be. On the other hand, the opportunity for new varieties was never greater, for we know we are working on a sure thing. The supremacy of H109 has taught us that. What has been done in securing a first class cane for the most productive fields on the Islands can be done for the less productive lands. There is an urgent need to have an "understudy" for every one of our standard canes. It is more than insurance against possible calamity. It is a necessity.

In this plea for more and better seedling work, there is no intention of belittling or depreciating the present enthusiasm and desire to secure by means of bud selection the improvement of cane varieties. I believe the two projects go hand in hand. There should be no conflict between them. Each deserves our immediate attention.

In this paper, I stress the seedling work only because I understand others more competent than I are to handle the other phase of cane improvement. However, I would like to say that in the history of plant breeding, the greatest resistance to disease has come about in varieties that have been produced by seedling work, in contrast to strains originating as bud sports.

The securing of new varieties by sowing the cane tassel, watching the tiny plants grow, transplanting them, and caring for them until they have developed cane stalks from which the first seed cane can be secured, is fascinating work. The most unskilled can do it. The Ewa school children raised several hundred seedlings last year. The more important future trials with frequent eliminations of the worthless canes requires patient testing and careful observations over a long period of time. There is that gambling element in this work which has its appeal. H109 was one chance out of 5000, but for the careful selection work of Mr. Eckart and his associates it might have been lost for all time. The Experiment Station and its staff needs the cooperation of every individual on the plantations who will raise a few seedlings.

In 1920 and 1921, at Ewa, there were five individuals who were propagating seedlings. At Olaa, Hilo Sugar Company, and Honomu there are plantation overseers and chemists who are raising seedlings to beat the old timer, Yellow Caledonia. The evolution of H109 at Ewa only encourages us to work harder for new varieties. We know at first hand what a seedling can do.

Since 1914, I venture to state that at Ewa more experimental area has been in seedling canes than on any other plantation, though Wailuku Sugar Company is running us a close second.

There are now 1094 seedlings under investigation covering a total of 90 acres. Ewa has almost 600 of her own propagation now being grown. This is in addition to 20 acres of the 1920, 1921 and 1922 bud selection experiments. I mention this merely to show how necessary we believe seedling work to be, in spite of the fact that H109 stands head and shoulders above all.

The profitable production of sugar in Hawaii will always be based on the growing of a suitable cane variety. Our conditions are so different on the same plantations and from one plantation to another that varieties adapted to every environment are necessary. We haven't them now. The chances of variety deterioration due to disease or inherent qualities are always present. Quarantine laws restrict the importation of any foreign varieties to meet our needs. Our salvation is the raising of new varieties through propagation of our own seedlings. If our interest in this endeavor lessens, let us remember that H109 had its beginning as a seedling and that there is every reason to believe that many more similar successes can be achieved in a like manner.

# The Availability of Plant Food As Measured By Plant Analysis.

*A REVIEW OF THE LITERATURE*

By W. T. McGeorge

In 1840, although based on earlier work of de Sausure, von Liebig advanced his mineral theory of plant nutrition. Following this we note numerous attempts to measure the plant food needs of the soil or plant. Such attempts have apparently reached their climax in the last few years as evidenced by the recent attitude taken by the Association of Official Agricultural Chemists, an organization of the leading chemists engaged in this field in United States. In their methods of analysis which are the "Hoyle" of agricultural chemistry, we note that the old official method of soil analysis has been discarded. In its stead has been suggested, but not adopted as official, the absolute determination of the mineral constituents. This would indicate that the "brains of the industry" had either given up in despair or had decided to start over again with a clean slate.

Attempts to correlate fertilization practices with soil composition have been along three rather definite channels: First, the analysis of the soil; second, the simulation of the feeding power of the plant by extracting the soil with weak acid solvents; and third, the analysis of the plant through the ash. In the smaller grain crops the latter method has been applied quite extensively. With numerous

other crops this method is possible but hardly practical and we might almost say with impunity that with sugar cane we reach the other extreme where circumstances make such a proceedure practically impossible.

A very novel method and one that presages considerable value has been suggested by Herbert Walker in the last *Record*, namely, the analysis of the crusher juice. It is possible by this means to obtain samples representing almost any desired section of the plantation. A somewhat similar proceedure was used by P. S. Burgess in his comparison of the potash content of molasses with the analysis of the soil, which, however, is limited to the plantation as a whole and lacks the advantages of the analysis of the crusher juice.

In view of the surprising lack of response to phosphate and potash on many of the Island sugar lands, it is obvious that any method which promises aid in the formulation of fertilizer practices is well worth a thorough study. It is interesting to note in this connection previous work on "the analysis of the soil through the medium of the plant."

This field of endeavor is quite thoroughly covered by Johnson in "How Crops Grow".[1] The information therein represents a general survey of the literature. Among the important points which he brings out are: different parts of the same plant yield unlike proportions of mineral matter; the upper and outer part of the plant contains the most mineral matter; the same plant in different stages of growth varies in proportion of mineral matter to dry matter; the influence of soil and season causes the proportion of mineral matter in the same plant to vary; different varieties of the same plant grown on the same soil will vary; ash content of healthy and vigorous plants varies from that of weak and stunted.

E. von Wolff has compiled thousands of ash analyses in his book "Aschen-Analysen von Landwirth-schaltlichen Producten Fabrik-Abfallen und Wild-wachsenden Planzen" which is a constant source of reference for agricultural chemists. Briefly stated, his data show a wide variation in the ash composition of the same plants grown under different environments.

Turning to more specific data we note the most extensive investigation of this problem is that of Hall[2] of the Rothamstead Experiment Station who reports in considerable detail his work on oats, wheat, barley, potatoes, swedes and mangels. This work so closely correlates local proceedure, even to a comparison of the citrate soluble phosphate in the soil, that it may not be amiss to present some of his data.

## Cereal Crops.

Oats were grown in pots on six different soil types, the plants analysed at maturity and the phosphate content of the ash compared with that in the soil soluble in 1% citric acid.

| Soil No. | Per Cent. $P_2O_5$ in Plant Ash (Average) | Per Cent. $P_2O_5$ in Soil Sol. In 1% Citric |
|---|---|---|
| 1.......... | 10.89 | .142 |
| 2.......... | 7.46 | .0401 |
| 3.......... | 6.10 | .0144 |
| 4.......... | 5.41 | .0115 |
| 5.......... | 4.80 | .0210 |
| 6.......... | 3.91 | .0023 |

Field experiments on these soils showed that only No. 6 was in need of phosphate fertilization. Hall found considerable variation in the phosphate content of the ash and from the results as a whole concludes that the analysis of the soil with 1% citric acid indicates the characteristics of the soil towards phosphate manuring much better than the analysis of the ash. For example he cites soils Nos. 5 and 6, the former of which does not respond to phosphate manuring, yet his analyses of individual plants showed some grown on soil No. 6 to have absorbed more phosphate than those grown on soil No. 5. It is clearly evident, however, in spite of his conclusions, that the averages are in remarkable accord.

He has further studied the influences of fertilization on the phosphate content of the ash and shows that a greater increase in citrate soluble phosphate is to be found in those soils fertilized for extensive periods than is shown in the analysis of the plants grown thereon. Extensive analyses of plants grown from season to season at Rothamstead indicate that an unmanured plot, impoverished in all directions, may yield produce with much the same ash composition as one that is rich, being equally supplied in all directions.

### Root Crops

Hall's analyses of swedes are given in the following table and compared with the citrate soluble phosphate in the soil:

| Soil No. | Per Cent. $P_2O_5$ in Ash | Per Cent. Cit. Sol. $P_2O_5$ in Soil |
|---|---|---|
| 1.......... | 8.96 | .0199 |
| 2.......... | 9.10 | .0129 |
| 3.......... | 10.56 | .0203 |
| 4.......... | 10.91 | .0123 |
| 5.......... | 11.18 | .0135 |
| 6.......... | 11.81 | .0088 |
| 7.......... | 12.77 | .0073 |
| 8.......... | 15.01 | .023 |
| 9.......... | 15.85 | .0324 |

Soils Nos. 1 to 6 have given response to phosphate manuring in field experiments, while Nos 8 and 9 have not. In commenting on these results he says that they are in very satisfactory accord.

Hall's general conclusions are that the proportion of phosphate in the ash of any given plant varies with the amount available in the soil. The extent of this variation is, however, limited and often no greater than that due to variation in season or other variations induced by difference in supply of ash constituents. These fluctuations are reduced to a minimum in the case of organs of plants which, like the grain of cereal crops and the tuber of potatoes, are manufactured by the plant from material previously assimilated. Root crops like swedes and mangels are more affected by changes, the phosphate requirement of the soil being well indicated by the composition of the ash of swedes grown unmanured although the extraction of the soil with 1% citric acid gives more decisive information.

While Hall's conclusions appear more or less adverse to the value of plant analysis as compared to the extraction of the soil with 1% citric acid it is evident that he interpreted his data with the idea in mind of finding a plant which could be generally adapted to measuring phosphate deficiencies.

Another extensive investigation in this field is that of B. Tollens[3]. He mentions among the factors which influence the variation in the composition of the ash, stage of growth, the soil, fertilizers, available moisture, and thickness of stand. He has tabulated the variation in the phosphate content of the ash of some typical plants as follows:

| Plant— | Per Cent. Ash | Per Cent. $P_2O_5$ in Ash |
|---|---|---|
| Meadow Hay ......... | 2.2-11.4 | 2.0-21.3 |
| English Rye Grass .... | 7.5-15. | 6.2-16.0 |
| Red Clover ........... | 4.5-9.2 | 4.0-15.0 |
| Winter Wheat ........ | 1.6-2.5 | 39.2-53.7 |
| Maize ................ | 1.0-1.7 | 37.6-53.7 |
| Winter Wheat Straw... | 4.5-7.0 | 2.2-8.9 |
| Potato Tubers ........ | 2.2-5.8 | 8.4-27.1 |
| Potato Leaves ........ | 5.2-12.9 | 2.6-12.1 |

He cites numerous experiments and analyses showing the composition of plant ash at various periods of growth and the needs of larger quantities of plant food at certain definite periods. Other experiments cited show variation in the composition of the ash of plants grown on different soils. The influence of fertilization on ash composition is also shown by experiments and analyses. Too much or too little water may influence the composition as shown by data cited, and the thickness of the stand is shown to be a factor in other analyses and experiments.

Tollens, while he points out the need of more extensive study, says that the fertility of a soil might be measured by growing crops adapted to the particular soil and analysing the plant.

Heinrich[4] has used the oat plant in measuring plant food defiiciencies and analysed only the roots. Where $P_2O_5$ content of the dry root fell below .08-.10% he concluded the soil was deficient. Dikow[5], in similar work on barley, fixed the minimum at .13% $P_2O_5$ in the dry roots. Helenkampf[6] carried on similar work and concluded that when there was an increase in $P_2O_5$ content of the dry matter of the crop as a result of fertilization the need was indicated. M. Stahl-

Shroder[7] tested Heinrich's system of root analyses and also another method, using the seed analyses and found the former to be of no value and, while the latter was not of general application, he suggested that it might be applied to particular climatic and soil conditions. Savvin[8] working on small grain crops found that the total $P_2O_5$ in the straw and in the entire plant can indicate the need of fertilization. If the phosphate supply is abundant it enters the plant in greater quantity. Herbert and Truffaut[9] claim from their experiments that a rational basis for fertilization may be furnished by the analysis of typical plants grown under normal conditions. They claim that in a given species of plant grown on a given soil, the use of fertilizer increases the yield but does not affect the mineral composition.

It is notable in reviewing the literature that little attention has been given to this method of studying soil deficiencies in United States. The only serious attempt is that of Hartwell[10] at the Rhode Island Experiment Station. At the outset of his experiments, using oats, millet and turnips, only in the latter crop did the per cent. phosphate appear to be markedly influenced by the available supply in the soil. He found a decided relation between the inorganic phosphate in the juice of the turnip and the available phosphate in the soil. His experiments were quite extensive and included analyses of crops from plot experiments in different sections of the state, grown under different soil conditions, environment, fertilization and moisture supply. The idea was to determine whether or not the turnip could be applied generally over the state as a measure of available phosphate in the soils of the state.

The following points which he cites may be of interest. The percentage of an ingredient in field crops may depend on one or more variable factors which may or may not affect absorption in the same degree. Even if the extent of the influences could be determined there would still be the difficulty of knowing which of the factors influenced the growth. His work, however, showed that "the percentage of phosphate is quite variable in the turnip, depending at least considerably on the amount of phosphate available in the soil". It is interesting to note that 70% of the phosphate in the turnip is inorganic and practically all soluble in the juice and that an increase in the supply of available phosphate in the soil increases the phosphate content of the juice in proportionately larger amounts than the total phosphate content of the turnip.

It was found that in similar seasons the percentage of phosphate in the turnip from soils in different sections of the state usually varied in the same direction as the amount of available phosphate in the soil, and it seems probable, especially under similar climatic conditions, that the relative amount of available phosphate in different soils may be indicated by the relation between the per cent. phosphate in the turnips grown on those soils. To illustrate the variation in the per cent. phosphoric acid in the dry matter of the turnip, .27% was found in the turnips grown on an extremely deficient soil while 1.82% was found in those grown on a soil abundantly supplied. He calls attention to the variation in the per cent. phosphate with the age of the plant, being much higher in the young plants as compared with the mature.

The writer[11] analysed buckwheat and millet plants grown in phosphate experiments on Hawaiian soils deficient in phosphate with and without phosphate

manuring and found little or no variation in the phosphate content of the plants. Attempts were made to grow turnips and radishes in these same experiments but were abandoned due to inability to protect the large number of pots from insect ravages.

## Summary.

A review of previous studies on the relation of available plant food to the mineral composition of the plant shows that this field of endeavor has not been given the attention in the United States which it has received in Europe. While more or less conflicting results have been obtained by different investigators, the more complete studies, we might conclude, indicate that the analysis of the crusher juice should lend valuable information regarding the available plant food constituents in our soils. It should be remembered, however, that the composition of the plant mineral matter varies at different periods of growth, that the amount of several mineral nutrients which a soil must furnish to a crop in the earlier stages of growth is greater than the crop contents at maturity, and that in the specific case of phosphate in our own soils, where the fixing power is so high that little or none added as fertilizer goes below the first foot, indicates that where a response is obtained on Hawaiian soils, it is due principally to its stimulating influence on the young cane.

## References.

[1]How Crops Grow.
[2]Jour. Agric. Science, Vol. I, p. 65.
[3]Exp. Sta. Record, Vol. VIII, p. 305.
[4]Exp. Sta. Record, Vol. XIII, p. 316.
[5]Exp. Sta. Record, Vol. XIII, p. 316.
[6]Exp. Sta. Record, Vol. XIII, p. 316.
[7]Exp. Sta. Record, Vol. XVI, p. 28.
[8]Exp. Sta. Record, Vol. XXXVI, p. 622.
[9]Exp. Sta. Record, Vol. XV, p. 763.
[10]R. I. Exp. Sta. Bull. 154.
[11]Haw. Exp. Sta. Bull. 41.

# Sugar Cane Improvement.

H8949, a seedling of H109, makes a good showing in comparison with the parent cane.

A field of selected Yellow Caledonia at Hakalau Plantation, planted June 6, 1922, and photographed in October. Photograph submitted by J. M. Robertson.

Wailuku No. 15, a promising seedling propagated in 1917, of Lahaina parentage.

# Recent Bud Selection Work.*

By A. D. Shamel.

Bud variations are of frequent occurrence in plants propagated by budding or other vegetative methods. As some one has said, "Variation is the only invariable thing in nature." The variations observed in vegetatively propagated plants may be classified, for the purpose of this discussion, as (1) those which are inherited, and (2) those which are not inherited. The inherited bud variations are the ones of importance in this discussion as the others are largely the result of changing environmental influences and are not, so far as we now know, of any direct importance in the work for the improvement of plants through bud selection.

The fundamental objects of our bud selection work include (1) securing new and better varieties through the selection of striking and valuable inherent bud variations; (2) the isolation and propagation of strains of established and commercially valuable varieties which possess characteristics of greater merit or value than those of the parent varieties; and (3) the bringing up of the average performance of the population of valuable strains to that exhibited by the maximum individual performance, or, as nearly so as is found to be practicable.

The Washington navel orange is a striking example in the citrus of the possibility of securing valuable varieties through the discovery and propagation of valuable bud mutations. About one half of the sugar production of the world derived from sugar cane is produced by varieties which originated as bud mutations. Within recent years a great industry has developed in the United States in the propagation of varieties of the Boston fern which have originated as bud variations. An ever-increasing mass of evidence is accumulating which shows beyond any question of doubt the importance of bud variations as sources of improved varieties of plants. I have brought together some of this evidence which has been published by the Experiment Station of the Hawaiian Sugar Planters' Association in a bulletin entitled, "The Improvement of Plants Through Bud Selection."

In our citrus varieties, as in other vegetatively propagated varieties of plants, numerous strains have originated as bud variations during the past fifty years and have been intentionally, or as has been more often the case, unintentionally propagated by nurserymen and growers. Some of these strains are valuable for the economic production of food products, while others are undesirable and worthless for commercial propagation.

In these citrus varieties we have isolated through bud selection several distinct strains of each of the varieties studied. On account of the lack of time it is impossible to discuss this work in detail here, but those who are interested will find it described in a series of U. S. Department of Agriculture bulletins:

*Paper read at the meeting of the Lemon Men's Club, California, August 2, 1922.

No. 623, A Study of Bud Variation in the Washington Navel Orange; No. 624, A Study of Bud Variation in the Valencia Orange; No. 697, A Study of Bud Variation in the Marsh Grapefruit and No. 813, A Study of Bud Variation in the Eureka Lemon; and No. 815, A Study of Bud Variation in the Lisbon Lemon.

In potatoes, sugar cane and many other crops, similar work for the isolation of strains has been or is now being carried on. When the strains have been isolated, their value compared and studied, the superior ones are multiplied through the propagation of the best individuals, and the inferior ones are eliminated so far as commercial propagation is concerned.

In the valuable strains inherent variations in the habits of production of the individual trees or other plants have been discovered. Through the selection of inherently superior parent plants for propagation it has been discovered that it is possible to bring up the average production of these strains to, approximately, that of the best individuals, in other words, to lay the foundation for the production of uniformly good crops.

The great economic possibilities of bud selection work, in my opinion, lie in the third phase of this work. The Utah Agricultural Experiment Station present in their bulletin, No. 176, entitled, "Potato Improvement by Hill Selection," definite scientific evidence on this point. The work described in this bulletin began with experimental propagations of good and poor potato hills in three commercial varieties. The progencies of the poor hills soon became so poor that their propagation had to be abandoned. As a result of the first experimental work, it was decided to concentrate on hill selections in the best variety.

The accompanying table shows a summary of the results of hill selection work with the Majestic variety as compared with unselected plant propagation material from the period from 1915 to 1920 inclusive.

MAJESTIC POTATO VARIETY

Yield in Bushels per Acre.

| Year. | Pedigree Selection | Unselected Stock | Pedigree Gain |
|---|---|---|---|
| 1915 | 316.7 | 179.3 | 137.4 |
| 1916 | 330.7 | 191.2 | 139.5 |
| 1917 | 382.4 | 269.3 | 113.1 |
| 1918 | 311.9 | 202.4 | 109.5 |
| 1920 | 146.9 | 117.3 | 29.6 |
| 1919 | 353.4 | 184.8 | 168.6 |
| | 307.0 | 190.7 | 116.3 |

Not only was the yield increased through hill selection by more than 60 per cent., but the commercial quality of the pedigree crops was much higher than that of the unselected. The pedigree potatoes possessed more uniformly good size, shape and other important tuber characteristics than the unselected.

At the Central Experimental Farm of Canada, located at Ottawa, a recent report shows that the root-grafted progeny of a high yielding parent healthy apple tree has produced during nine years an average increase of more than 60 per cent., as compared with the yield of a similar progeny from a low yielding

parent tree. In this instance there are no apparent type differences in foliage or fruit characteristics of the parent trees. Top worked progenies of these parent trees showed similar differences in behaviour to the root grafted progenies. Therefore we are forced to the conclusion that in this case the characteristic number or quantity of apples was transmitted from the parent trees to their progenies.

An interesting progress report may be made upon the behaviour of several lemon progenies on the Limoneira and Sespe ranches. While there are no comparative poor yielding progenies available for study in these instances the early, heavy, and uniformly good production of the trees in their progenies grown from carefully selected buds secured from high yielding parent trees is significant. The members of this club who have seen these trees are aware of the remarkable uniformity of tree and fruit characteristics. These trees are so strikingly superior that they excite the admiration of every one who sees them.

LEMON PROGENIES.

Yield in Field Boxes per Tree.

| Limoneira Lisbon Trees. 650 Trees Planted in 1913. | | Sespe Eureka Trees. 823 Trees Planted in 1916. | |
|---|---|---|---|
| Year. | Yield. | Year. | Yield. |
| 1917 (for 7 mo.) | 0.69 | | |
| 1918 | 2.53 | 1918 (for 7 mo.) | 0.24 |
| 1919 | 3.83 | 1919 | 0.68 |
| 1920 | 5.45 | 1920 | 0.74 |
| 1921 | 7.36 | 1921 | 1.90 |
| 1922 | 10.00 Est. | 1922 | 3.00 Est. |
| (1922—7.57 for 7 months) | | (1922—2.26 for 7 months) | |

While the Lisbon and Eureka progenies are located on different ranches with different environmental conditions and are not comparative, these yield data have been shown in the accompanying table for comparative years from the time of planting. Only very few bud variations have been found thus far amongst the 650 Lisbon trees and a similarly small number have appeared in the 823 Eureka trees. The heavy yields of particularly uniformly good fruits in these progenies can be safely ascribed in large measure to bud selection.

Other recent examples of similar improvements in yield, both as regards the quantity and the uniformly good commercial quantity, with several vegetatively propagated crops might be cited if time permitted. Enough has been said, I believe, to demonstrate the great importance of this work from the standpoint of profitable fruit growing and farming. A vast amount of work along this line is now under way with many crops and the future will show much greater progress than the past. We have just begun to realize the significance of this work, to understand methods of parent plant selection and progeny tests, and to concentrate upon this subject, so that effective work is now possible. There is no mystery about it, only plain common sense, combined with intelligent and

sustained effort. It requires work but the compensation for the work required is far beyond its cost.

The work deemed necessary in order to maintain and improve our established varieties of citrus fruits and to secure its benefits may be divided into two phases, (1) investigation, and (2) commercial.

The investigational bud selection work in the citrus conducted by the United States Department of Agriculture in California was begun in April, 1909, and has been continued uninterruptedly to date. It has included a systematic study of the important commercial varieties by means of individual tree studies in suitably isolated orchards. Most of this work has been carried on in privately owned orchards and with the hearty co-operation of the owners of these properties. It has been done with a minimum of expense. It has been continuous. It has been conducted from the standpoint of discovering the facts. The results have been presented from time to time through demonstrations, conferences with growers, and by means of publications which reach the citrus growers generally. All of this effort in co-operation with the growers, the organizations representing the growers, and with all others concerned, has for its sole object the improvement of production by the industry as a whole for the benefit of both the producers and the consumers of citrus fruits.

During the early stages of the investigational work the individual tree studies were carried on in established orchards. Many strains of the established varieties were discovered which have arisen from bud variations. Some of these strains were found to be valuable while many proved to be undesirable. Careful selections of parent trees were made in the best strains, and progenies propagated in order to lay the foundation for securing inherently superior strains. Some parent trees of inferior strains were selected for propagation so that a comparison of the progenies from selected trees of the good and poor strains can be secured. High and low yielding parent trees in each of the important strains were selected for experimental propagation. We are now engaged in a study of the progency behaviour of these parent trees. Enough evidence has been secured thus far to warrant the statement that the superior and inferior strains of our citrus varieties can be isolated through bud selection. Furthermore, the progenies of the highest yielding parent trees have thus far given us the highest and best yields, while the progenies of the low yielding parent trees of these same strains have given us the lowest and most undesirable yields. Surely the members of this club will appreciate the tremendous and fundamental significance of these facts.

The investigational work now under way is mainly concerned with the progeny behaviour of carefully selected parent trees. The object is to locate the best progenies for further propagation. In order to secure comparative data it is also essential to study the progenies of inferior parent trees. Enough of this work is being done to secure adequate comparative data. The main effort, however, is to lay the foundation for further improvements of our valuable varieties by the propagation and study of a large number of progenies of the best trees.

I am of the opinion that the established citrus varieties are the most valuable possession of the citrus industry. Without them our efforts would go for naught. These varieties may run out or deteriorate through the intentional or unintentional propagation of undesirable strains arising from bud variations.

Through systematic bud selection we cannot only maintain our varieties, but also improve their production by eliminating the undesirable strains and propagating only the inherently superior progenies.

The commercial phase of this work is the practical use and application of the results of the investigational phase. It is being carried on by co-operative citrus organizations and by individual effort. In order to illustrate the development of this phase, the work of the California Fruit Growers' Exchange will be cited. In May, 1917, this organization established a bud department of the Fruit Growers' Supply Company. C. S. Milliken was placed in charge of this department and its success has been due to his untiring and unselfish efforts and the work of his associates. Since its organization this department has furnished to propagators and growers more than 2,000,000 buds secured from superior parent trees located in many of the best orchards in this state. The work has been self-supporting, a charge being made for the buds sufficient to cover the cost of securing and distributing them. In this work, Mr. Milliken has had the public-spirited support of the leading citrus growers from whose orchards the buds were secured, the nurserymen and growers using the buds, and of every one concerned with the future as well as the present welfare of the industry. This unparalleled demonstration of co-operative effort has already inspired other industries to similar effort and marks an epoch in the history of the world's work for economic food production. While this work has been quietly carried on, and for this reason may have escaped the publicity often secured by more widely advertised efforts, it nevertheless appeals to me as the most important and genuinely successful effort to develop and improve production by an industry as a whole thus far achieved in the history of mankind. It also demonstrates the possibility of an organized agricultural industry as a whole utilizing the results of scientific investigation.

In conclusion, I want to discuss briefly from my point of view, some of the things remaining to be done in order to develop this work to its logical conclusion.

From the investigational side, it appears to me that we are now ready to carry on a more effective search for improved bud variations as possible sources of improved strains and varieties. Owing to our very limited resources we have been able to do thus far only a small amount of systematic search for such bud variations. With the growing interest in this phase on the part of growers and through better resources it now seems possible to achieve this ambition. It means, as I understand it, the systematic search not only of our own orchards, but of citrus orchards in all parts of the world. We should concentrate not only upon California and Florida orchards, but study those in the Mediterranean region and other citrus districts as well.

The progeny records now under way will require several years before final and conclusive data can be secured. Many more progeny studies than those now available must be made. It is in this phase of our work that our efforts will be most strongly concentrated during the next few years.

Co-operative individual tree performance records are of great value in this work. We desire the co-operation of all citrus growers in securing accurate individual tree records of yields. From these data, as has already been demonstrated, definite and reliable information can be secured not only as to location

of superior or inferior producing trees, but as to the effects of different methods of cultural care and other conditions affecting citrus tree behavior. This individual tree record work is not only of direct benefit to the grower performing it, but to the industry as a whole. Out of it is destined to come definite and accurate information as to orchard practices which will be of practical importance to every one concerned in this industry.

The future work of the commercial phase, as I see it, includes not only (1) continuing the work of securing reliable bud wood from superior parent trees for propagation, but (2) the development of improved sources of bud wood through the selection of superior parent trees in the best progenies, (3) the development of reliable sources of supply of improved root stocks (4) the building up of authoritative information as to varietal adaptations, propagating and planting conditions, and the guiding of propagation work along safe and constructive lines, (5) the utilization of the results of scientific investigation along these and related lines so that the individual grower can secure the benefit of this work. This is an ambitious program, but one which experience has proven to be practicable in the California citrus industry.

In order to achieve success in both the investigational and the commercial phases of this work, the active co-operation of all of the growers must be secured. The members of this club, with whom I have had the pleasure of long and active association, have always led in such co-operative efforts. I feel that we have now reached a point where we can logically ask for your further co-operation in the development of this project to its final and complete success. In this connection as I now see it, more individual tree records in bearing orchards, and the planting of young orchards in such a way that progeny records can be secured, are the most important matters for consideration.

We would like the opportunity of consulting with prospective planters in order that we may help them plan the arrangement of progeny planting in the orchards. This most important work has to be done when the orchards are planted. There are no disadvantages in the progeny form of planting. It lays the foundation for a steady and sound improvement of our varieties through progeny studies. In my opinion it is the most effective way through which bud selection work for the amelioration of our citrus fruits can be conducted. Therefore, the citrus planters who co-operate in this work will not only secure advantages accruing from this work, but will contribute directly and effectively to the future success of our industry. We ask for the co-operation of the members of the Lemon Men's Club in this far-reaching and fundamental effort.

We are ready and anxious to co-operate in all such work. It pays, not only individually but from the viewpoint of the progress of this industry as a whole. With concentrated effort and sustained interest on the part of every one concerned, I am convinced that much greater progress is probable during the next ten years than has been possible during the past ten years of pioneer effort.

# Varieties at Kilauea.

## Kilauea Experiment 28, 1922 Crop.

In this experiment, plant Yellow Caledonia cane produced more sugar than either D1135 or Badila. D1135 yielded more cane than Caledonia but, due to poorer juices, less sugar. Badila had slightly better juice than Caledonia, but this gain was more than offset by the larger tonnage of cane in the Caledonia and D1135 plots. All the cane was affected by rats, but the Badila suffered far more in this respect than did the other varieties.

### VARIETY TEST

Kilauca S.P. Co. Exp. 23, 1922 Crop

Field 37.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.1<br>Y.C.<br>34.35 | 1.2<br>Badila<br>24.02 | 1.3<br>D1135<br>32.94 | 1.4<br>Y.C.<br>30.94 | 1.5<br>Badila<br>25.90 | 1.6<br>D1135<br>38.99 | 1.7<br>Y.C.<br>35.35 | 1.8<br>Badila<br>28.49 |
| 2.1<br>D1135<br>36.24 | 2.2<br>Y.C.<br>30.09 | 2.3<br>Badila<br>26.85 | 2.4<br>D1135<br>36.85 | 2.5<br>Y.C.<br>36.02 | 2.6<br>Badila<br>28.36 | 2.7<br>D1135<br>35.74 | 2.8<br>Y.C<br>34.55 |
| 3.1<br>Badila<br>28.14 | 3.2<br>D1135<br>35.55 | 3.3<br>Y.C.<br>32.60 | 3.4<br>Badila<br>34.70 | 3.5<br>D1135<br>31.57 | 3.6<br>Y.C.<br>34.47 | 3.7<br>Badila<br>26.43 | 3.8<br>D1135<br>34.05 |
| 4.1<br>Y.C.<br>31.77 | 4.2<br>Badila<br>26.27 | 4.3<br>D1135<br>43.30 | 4.4<br>Y.C.<br>39.63 | 4.5<br>Badila<br>26.63 | 4.6<br>D1135<br>40.53 | 4.7<br>Y.C.<br>35.14 | 4.8<br>Badila<br>31.02 |

Ditch

### Summary of Results

| Variety | No. of Plots | Yields Per Acre | | |
|---|---|---|---|---|
| | | Cane | Q.R. | Sugar |
| Badila | 11 | 27.90 | 8.45 | 3.30 |
| Yellow Caledonia | 11 | 34.08 | 8.52 | 4.00 |
| D1135 | 10 | 35.67 | 10.30 | 3.55 |

The soil in the field in which these varieties were planted is heavy and comparatively unproductive. Previous to planting, the entire field received a uniform dose of stable manure and sand. One thousand pounds of reverted phosphate were placed in the furrow with the seed. All plots received uniform doses of nitrogen totalling about 150 pounds per acre.

The varieties were planted August, 1920. The Badila seed was spaced about three inches. The Caledonia seed was planted end to end and the D1135 seed was lapped about one and a half. The harvesting results follow:—

| Plots | Cane | Q. R. | Sugar |
|---|---|---|---|
| Caledonia ....... | 34.08 | 8.52 | 4.00 |
| D 1135 .......... | 36.57 | 10.30 | 3.55 |
| Badila ........ . | 27.90 | 8.45 | 3.30 |

The Badila cane seems to ratoon very well in this section, probably even better than Caledonia or D1135, so the continuation of this experiment on the ratoon crops will be very interesting to watch.

## Details of Experiment.

*Object*—

To determine the most profitable variety of cane to raise on the heavy mauka soils of Kilauea.

*Crop*—

Badila, Caledonia and D1135 plant cane.

*Location*—

Field 37.

*Layout*—

Number of plots—32.

Size of plots—1/10th acre (80.6′ by 54′).

Plots consist of 12 straight lines each 80.6′ by 4.5′.

*Plan*—

| Plots. | No. of Plots. | Nitrogen. | Rev. Phos. |
|---|---|---|---|
| Badila ................. | 11 | 150 | 1000 |
| Caledonia .............. | 11 | 150 | 1000 |
| D1135 ................. | 10 | 150 | 1000 |

Experiment planned, laid out and harvested by J. H. Midkiff.

Juice analyses by R. Spreckles.

J. H. M.

# Mole Cricket Injury at the Manoa Substation.

By O. H. Swezey.

On November 4, 1922, my attention was called to the injury done by the mole cricket (*Gryllotalpa africana*) to seed cane planted in a newly cleared field at the Manoa substation. I visited the place with Y. Kutsunai and made observations on the extent and nature of the work done by this insect.

The field was nearly an acre in extent, and is situated in the midst of a grassy region where there is also much honohono, in a wet region near a small stream, and just beyond the other cane fields at the substation. It had been cleared up but a short time previously and had been planted almost immediately thereafter. In the planting each seed used had three eyes, but the two end eyes had been gouged out purposely, leaving only the middle one to grow. When the new shoots appeared above ground, the stand was so thin that, digging to ascertain the cause, the work of the cricket was revealed. Where no shoot had appeared above ground, the eye had been eaten out by a mole cricket. So many of these had been eaten that there was a stand only of twenty per cent. Some shoots had started and then had been gnawed into near the base so that they died.

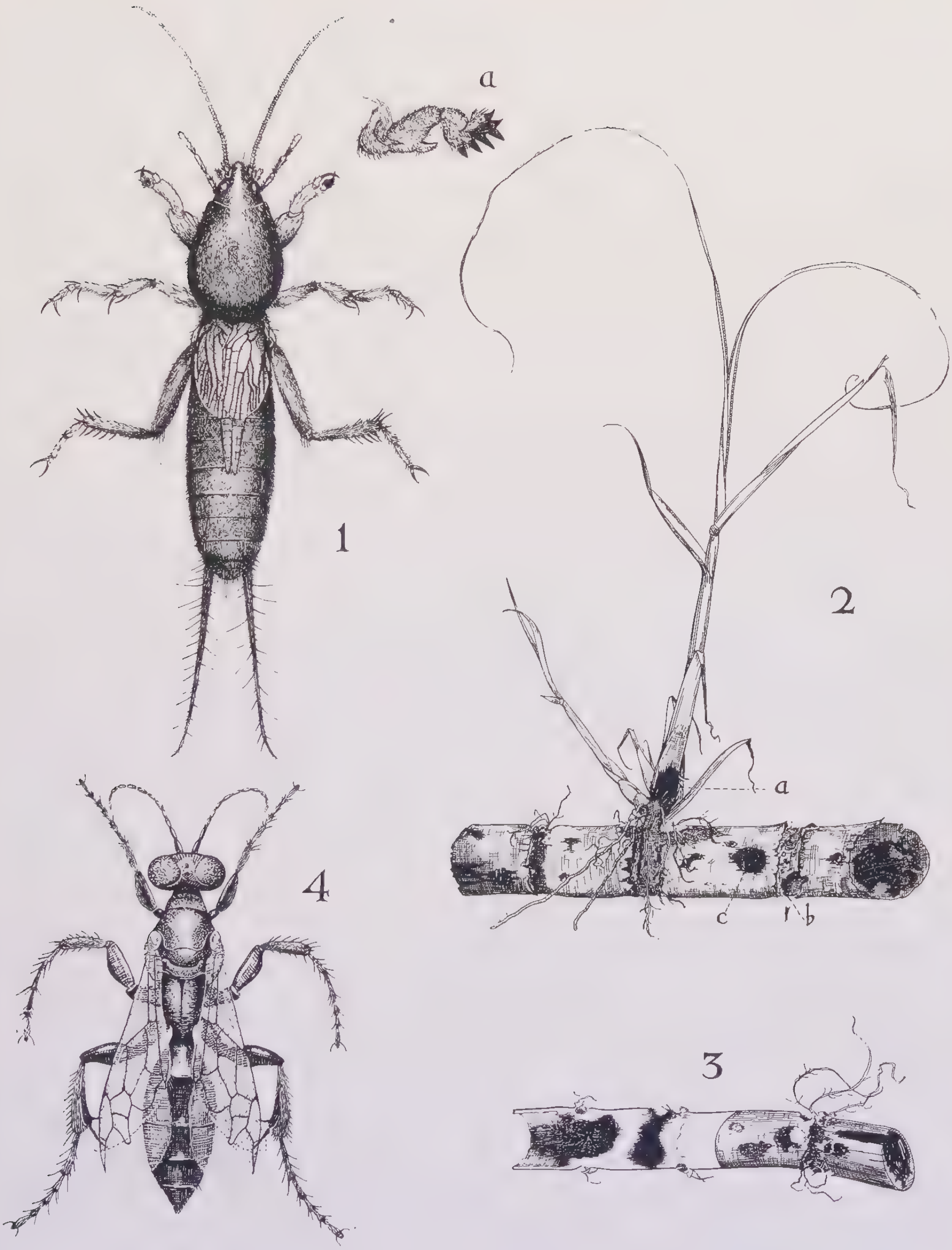
The injury by the crickets was not confined to the eyes, but the root-bands were gnawed off as well, and holes were eaten through the rind into the interior of the seed. These were of varying depths, from just starting to all the way through. They also ate into the ends of the seeds, usually completely excavating clear to the nodal tissue, and sometimes even penetrating this and traversing the full length of the seed.

In examining this work it was sometimes found that half a dozen successive seeds were entirely destroyed. The crickets were found in burrows alongside of the seeds, or nearby. They were all adults.

This is the first time that we have observed so great injury by the mole cricket in the Hawaiian Islands. The insect has been known on Oahu for a long while. It was first found on Kauai at Waimea in March, 1917. It is not yet known to the entomologists on the other islands. Heretofore its presence has been known at times in wet places on all the plantations of Oahu. The injury to the cane has been done chiefly by the crickets eating into the canes that were lying on the ground in wet places, and at times to a slight extent by eating out eyes of recently planted cuttings. Then, too, cause of complaint has been found due to the crickets burrowing into irrigation ditch banks, causing seepage and loss of water to the adjoining fields.

A mole cricket of a different species occurs in Porto Rico and the West Indies, where it is one of the serious pests. In Porto Rico the best control measure in cane has been to plant the seed leaving on the leaf sheaths, and placing it in a slanting position so that one or more eyes are above the surface, afterwards hilling slightly when the new shoots are started.

In various parts of the world there are wasps which prey on mole crickets. F. X. Williams found two of these in the Philippines in 1921 and endeavored to introduce them into Hawaii. About one dozen adult wasps were liberated at the Manoa substation. No evidence of their having become established has been observed.




MOLE CRICKET AND INJURY TO CANE "SEED."

1. Adult Cricket, × 2.
1a. Front leg showing modification for digging, × 3.
2. Cane "seed" showing injury by mole cricket, × ⅓.
2a. A young shoot has been eaten into and killed, and another new shoot has started below and at the left.
2b. Where an eye has been eaten out. The root-band has also been gnawed.
2c. Hole eaten through the rind.
3. A much eaten "seed," partially sectioned to show internal injury, × ⅓.
4. A Philippine wasp parasitic on the mole cricket, × 3½.

# Points of Accuracy in Sucrose Determinations in Waste Molasses.

By H. A. Cook.

## Influence of Zinc Dust on Volume of Solution for Invert Reading.

When the Hawaiian Chemists' Association adopted the new and simplified inversion method for the determination of sucrose in molasses and other sugar products, as proposed and worked out by Herbert S. Walker, supplimentary insruction sheets were sent out from this station. These instructions read in part as follows:

Pippette 75 cc. of the original filtrate into a 100-110 cc. flask, add 2 cc. 1-1 hydrochloric acid, mix, introduce a thermometer into the flask, which is then placed in a water bath heated to 70°-73° C. Shake occasionally till the thermometer in the flask indicates 65°-67° C. Remove from the bath and add 10 cc. 1-1 HCL. Allow the flask to stand at room temperature for half an hour or longer; add a little more zinc dust than is necessary to precipitate the lead, cool to the temperature at which the direct reading was made, and make up to 110 cc. with water at the same temperature. Mix thoroughly, filter and read the solution in a 200 mm. water-jacketed tube, noting the temperature accurately, which should be within one degree of that for the direct reading.

In the original work of Mr. Walker the directions read:

Allow the flask to stand at room temperature for half an hour or longer, cool to the temperature at which the direct reading was made and make up to 110 cc. with water at the same temperature. Mix thoroughly, add a little more zinc dust than is necessary, etc.

It is noticed that in the original case the zinc dust was added after the solution was made up to the required volume. Adding the zinc dust before making to the required volume will necessarily change the volume of the solution in the flask. How much of a change depends upon the amount of zinc dust added. The question has been raised several times as to how much this will influence the result of the sucrose determination.

Some time ago I made a few analyses on molasses in connection with my routine work on the above question. The results are as follows:

| Sample No. | Direct Reading | Invert Reading (1) | T°C. | Invert Reading (2) | T°C. | Sucrose % (1) | Sucrose % (2) | Difference |
|---|---|---|---|---|---|---|---|---|
| 1 | 31.32 | —16.73 | 26.9 | —16.77 | 27.0 | 37.38 | 37.42 | 0.04 |
| 2* | 27.87 | —16.40 | 27.1 | —16.72 | 26.8 | 34.47 | 34.67 | 0.20 |
| 3 | 28.72 | —14.93 | 27.0 | —15.01 | 26.8 | 33.97 | 34.00 | 0.03 |
| 4* | 28.76 | —17.23 | 27.4 | —14.57 | 27.7 | 35.84 | 35.96 | 0.12 |
| 5* | 30.35 | —17.65 | 27.1 | —16.60 | 26.5 | 37.37 | 37.50 | 0.13 |
| 6 | 30.20 | —14.56 | 27.3 | —14.57 | 27.3 | 34.87 | 34.88 | 0.01 |
| 7* | 27.47 | —17.53 | 27.4 | —17.68 | 27.8 | 35.07 | 35.24 | 0.17 |
| 8 | 25.26 | —15.12 | 27.5 | —15.15 | 27.8 | 31.48 | 31.54 | 0.06 |
| 9* | 24.13 | —17.72 | 27.3 | —17.75 | 27.4 | 32.61 | 32.64 | 0.03 |
| 10* | 25.89 | —14.88 | 27.4 | —15.09 | 27.2 | 31.78 | 31.91 | 0.13 |
| | | | | | Average | 34.48 | 34.57 | 0.09 |

*Very dark solutions requiring large amounts of zinc dust.

Invert Reading (1)=Adding requisite amount of zinc before cooling and making to the mark.

Invert Reading (2)=Adding the requisite amount of zinc after cooling and making to the mark.

Sucrose (1)=Adding requisite amount of zinc before cooling and making to the mark.

Sucrose (2)=Adding requisite amount of zinc after cooling and making to the mark.

The foregoing results show that the zinc should in all cases be added after the solution has been cooled, made to the proper volume and thoroughly mixed. However with the exception of the two results with the greatest difference, 0.20 and 0.17, the results are as close as any method can be expected to check on a product like molasses. Even in these two instances the results are as close as it is often possible to come on very dark solutions such as these were.

The difference in sucrose results shown above will make a difference in the gravity purity of the molasses as follows: Taking a brix of 88.5 and the sucrose showing the greatest difference, i. e., 0.20, there will be a difference of 0.23 in the gravity purity. Using the average difference in sucrose results, i. e., 0.09, there will be a difference of 0.10 in the gravity purity.

## INFLUENCE OF VARYING AMOUNTS OF ALUMINUM SULFATE ON THE DIRECT READING IN SUCROSE DETERMINATION.

From Browne's Handbook of Sugar Analysis the following is taken:

### Action of Lead Subacetate on Rotation of Fructose.

While the specific rotation of sucrose under the ordinary conditions of analysis is not modified sufficiently by subacetate of lead to introduce serious errors, the case is otherwise with fructose. Gill first showed, in 1871, that the specific rotation of fructose was greatly diminished by the presence of subacetate of lead, this decrease being so great that in the presence of sufficient basic lead the rotation of invert sugar ($[\alpha]^{20}_{D} = -20$) was changed to the right. This change in rotation is due to the formation of soluble dextrotary lead fructosate, the presence of which even in small amounts is sufficient to reduce the figure for the rotation of fructose ($[\alpha]^{20}_{D} = -92$) below that of glucose ($[\alpha]D = 52.5$).

I had occasion to verify the above in a series of sucrose determinations on molasses. The volume of solution used for the direct reading was changed from 50-55cc. to 100-110cc. without making sufficient increase in the amount of aluminum sulfate added. The sucrose results obtained were all high.

To show the effects of varying amounts of aluminum sulfate the following readings were made on the same filtrate varying the dilution and the amount of aluminum sulfate added:

1. 50cc. filtrate, 1cc. aluminum sulfate, diluted to 55cc reading=12.28
2. 50cc. filtrate, 2cc. aluminum sulfate, diluted to 55cc. reading=11.95
3. 50cc. filtrate, 5cc. aluminum sulfate, diluted to 55cc. reading=11.96
4. 100cc. filtrate, 2cc. aluminum sulfate, diluted to 110cc. reading=12.32
5. 100cc. filtrate, 3cc. aluminum sulfate, diluted to 110cc. reading=11.95
6. 100cc. filtrate, 4cc. aluminum sulfate, diluted to 110cc. reading=11.95

The following table gives comparisons of the sucrose results using the two different volumes and different amounts of aluminum sulfate:

| Sample No. | Dilution. | No. cc. Aluminum Sulfate | Readings | | Temperature Degrees C. | Sucrose |
|---|---|---|---|---|---|---|
| | | | Direct | Invert | | |
| 1 | 100-110 | 2 | 12.16 | —5.77 | 27.7 | 30.99 |
| 1 | 50- 55 | 2 | 11.95 | —5.77 | 28.0 | 30.68 |
| 1 | 100-110 | 3 | 11.95 | —5.77 | 28.0 | 30.68 |
| 1 | 100-110 | 4 | 11.95 | —5.77 | 28.0 | 30.68 |
| 2 | 100-110 | 2 | 13.63 | —5.80 | 28.6 | 33.46 |
| 2 | 100-110 | 4 | 12.53 | —5.98 | 27.4 | 31.95 |
| 2 | 100-110 | 5 | 12.53 | —5.98 | 27.4 | 31.95 |
| 3 | 100-110 | 2 | 14.24 | —6.24 | 27.5 | 35.18 |
| 3 | 100-110 | 4 | 13.21 | —6.34 | 27.9 | 33.85 |
| 3 | 50- 55 | 2 | 13.14 | —6.34 | 27.9 | 33.73 |
| 4 | 100-110 | 2 | 17.28 | —5.68 | 29.5 | 39.10 |
| 4 | 100-110 | 5 | 17.17 | —5.73 | 28.3 | 38.82 |
| 4 | 50- 55 | 2 | 17.22 | —5.73 | 28.3 | 38.89 |
| 4 | 50- 55 | 3 | 17.16 | —5.73 | 28.3 | 38.79 |
| 5 | 100-110 | 2 | 14.08 | —6.75 | 27.5 | 35.99 |
| 5 | 100-110 | 4 | 12.90 | —6.98 | 28.2 | 34.74 |
| 5 | 50- 55 | 2 | 12.90 | —6.98 | 28.2 | 34.74 |
| 6 | 100-110 | 2 | 13.01 | —6.07 | 27.8 | 32.95 |
| 6 | 100-110 | 4 | 12.13 | —6.30 | 27.8 | 32.06 |

It is thus shown that it is essential that sufficient aluminum sulfate be added to restore the specific rotation of the fructose. It is shown that for a volume of 50cc. diluted to 55cc. it requires 2cc. of a saturated solution of aluminum sulfate, and for a volume of 100cc. 4cc. of the aluminum solution is required. A little more does not influence the results.

## Influence of the Temperature on Inversion in Sucrose Determinations.

In using Herzfeld's modification of the Clerget method of analysis of sucrose it has always been maintained that in order to secure correct results it was necessary to follow very closely the details of procedure. This is especially true in regard to the amount of hydrochloric acid added and the details of heating. This is to place the solution to be inverted into a water bath with the temperature so controlled that the solution will reach a temperature of 69°C. in 2½ to 5 minutes and maintain a temperature of between 68° and 69°C. for exactly five minutes, then cooling the solution to the required room temperature as rapidly as possible.

In Browne's *Handbook of Sugar Analysis*, page 268, we find the following:

> The inversion method of Herzfeld gives correct results only when the prescribed conditions of concentration, amount of acid, volume, temperature and time of inversion are carefully followed.

In Mr. Walker's modification of the Herzfeld method considerable study and attention was given to the temperature at which the hydrochloric acid was added to the solution. In this method the temperature has considerable wider latitude than in any other method, being between 65° and 67°C.

In *Sugar,* Volume 24, May, 1922, is found the following extract:

In using Herzfeld's modification of the Clerget method in the analysis of molasses, E. Freibauer confirmed Koydl's opinion (Oesterr. Z. Zukerind, 1897, 503) that it is unnecessary to limit closely the temperature at which the inversion with HCL takes place. The same results were obtained by placing the solution to be inverted for ten minutes in a water bath previously heated to 90° C. as at 69° C.

As the above statement contradicted nearly all of the authors on the subject, I wished to test the method. Instead of using the Herzfeld modification, I used that in use by the H. C. A. which has been found in all cases to give results as close as those by the Herzfeld method. For comparison I used 75cc. of the filtrate, added 5cc. HCL Sp. Gr. 1.19, and placed the solution in a water bath heated to 90°C. for ten minutes. The results of five determinations are as follows:

| Sample No. | Direct Reading | Invert Reading H. C. A. Method | Invert Reading Heating to 90°C. | Sucrose H. C. A. Method | Sucrose Frei-bauer Method | Differ-ence |
|---|---|---|---|---|---|---|
| 1 ...... | 30.35 | —17.65 | —16.72 | 37.37 | 36.60 | 0.77 Lower |
| 2 ...... | 27.47 | —17.53 | —15.52 | 35.07 | 33.61 | 1.46 Lower |
| 3 ...... | 25.16 | —15.31 | —15.12 | 31.53 | 31.40 | 0.13 Lower |
| 4 ...... | 24.13 | —17.72 | —16.48 | 32.61 | 31.63 | 0.98 Lower |
| 5 ...... | 25.89 | —14.88 | —14.32 | 31.78 | 31.29 | 0.49 Lower |

The above results confirm all that has been maintained heretofore in following the details of the Herzfeld method.

## Carbon Bisulfide For Cane Grubs.

Recent experiments in the use of carbon bisulfide for killing cane grubs in Queensland have proved successful, according to a report of these experiments carried on by the Colonial Sugar Refining Company at Greenhills, and reported on by E. Jarvis in the *Australian Sugar Journal,* August 4, 1922.

A photograph in the *Journal* showed a plot of Badila cane, taken a few months after treatment, in which the section treated with carbon bisulfide was nine feet high, while the untreated section was only seven feet high, due to the effect of grubs feeding on the roots. The former received one-half ounce of carbon bisulfide to each stool (one-fourth ounce on each side); otherwise the conditions and care of both plots were the same. No mention is made of the cost of this treatment, but it was considered notably successful.

It is pointed out that the carbon bisulfide should be applied as soon as it is known that grubs are present, before the cane has become affected, but not until the termination of the egg-laying period.

Mention is made of previous experiments which showed it to be possible to fumigate successfully not only the grubs, but both pupae and eggs of the grey-back cane beetle. It is said that the egg shell, although leathery in texture, is slightly porous and offers little or no resistance to the entrance of bisulfide fumes.

In an earlier report by J. F. Illingworth, published in Bulletin No. 8, Division of Entomology, Queensland Bureau of Sugar Experiment Stations, 1919, success is ascribed to the use of carbon bisulfide at Gordonvale. About the same size charge was used and when applied to both sides of the stool it resulted in a complete killing of the grubs.

In neither of the cases reported was there any mention of injury to the cane by the carbon bisulfide. In the second instance, however, Mr. Illingworth remarks that "evidently the rains which followed a day or so after the application saved the cane from any ill-effects of the chemical."

O. H. S.

# Report of the Committee on Mill Equipment.*

By W. v H. Duker.

In preparing a report for this meeting your committee has had in view the benefit derived from frequently reviewing and discussing the various improvements made in our mill equipment during the past years, and has sent out a letter requesting the various members to ask what changes have been made either by installing or discarding equipment.

It is important for all of us to know when something new comes up, and it is also of equal importance that we know when any novelty is later discarded and the reason why.

Quite a number of replies have been received which should furnish ample material for discussion.

## REVOLVING KNIVES

A few years ago no season passed but a new type of knives was proposed. Lately very little has been said in this respect, and I think we are interested to know whether I am right in stating that at one time we overestimated the benefit derived from cutting up the cane very finely, and that we have now gone back to the idea that the object has been fulfilled as long as the knives are so arranged that they level the cane down so as to assure an even feed.

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*Presented at the First Annual Meeting of the Association of Hawaiian Sugar Technologists, Honolulu, November 15-18, 1922.

## SHREDDERS

Every now and then the question comes up as to whether or not the shredder is a successful part of the equipment, and if those who have installed one have found it an advantage.

I have compiled a statement giving the results obtained in the factories equipped with shredders from 1914 on.

I have compiled a statement giving the results obtained in the factories not be considered. But in practically every instance either the capacity or the extraction, or both, show an increase. This does not necessarily mean that a shredder is a desirable feature in every mill, and I think experience has shown that unless the other equipment of the factory balances with that of the mill equipment no success can be expected.

FACTORY No. 34

| Crop | Equipment | Tons Cane per Hour | Dilution | Extraction |
|---|---|---|---|---|
| 1914 | Crusher 60″<br>12 R. M. 66″ | 34.41 | 29.24 | 96.75 |
| 1915 | Crusher 60″<br>12 R. M. 66″ | 36.34 | 41.36 | 97.73 |
| 1916 | Crusher 60″<br>12 R. M. 66″ | 36.53 | 39.87 | 98.05 |
| 1917 | Knives<br>S-54″ 12 R. M. 66″ | 36.79 | 43.4 | 98.31 |
| 1918 | Crusher 60″<br>S-54″ 12 R. M. 66″ | 37.61 | 42.8 | 98.40 |
| 1919 | Crusher 60″<br>S-54″ 12 R. M. 66″ | 39.29 | 40.58 | 98.58 |
| 1920 | Crusher 60″<br>S-54″ 12 R. M. 66″ | 37.03 | 44.08 | 98.61 |
| 1921 | Crusher 60″<br>S-54″ 12 R. M. 66″ | 33.4 | 42.3 | 98.8 |

FACTORY No. 10

| Crop | Equipment | Tons Cane per Hour | Dilution | Extraction |
|---|---|---|---|---|
| 1914 | Crusher 54″<br>12 R. M. 72″ | 53.75 | 26.54 | 96.20 |
| 1915 | Knives Crusher 54″<br>12 R. M. 72″ | 55.98 | 34.19 | 96.32 |
| 1916 | Knives Crusher 54″<br>S-54″ 12 R. M. 72″ | 57.12 | 42.38 | 96.72 |
| 1917 | Knives Crusher 54″<br>S-54″ 12 R. M. 72″ | 59.55 | 38.47 | 97.25 |
| 1918 | Knives (2) Crusher 54″<br>S-54″ 12 R. M. 72″ | 57.68 | 33.45 | 97.22 |
| 1919 | Knives Crusher 60″<br>S-54″ 12 R. M. 72″ | 56.29 | 36.34 | 97.45 |
| 1920 | Knives Crusher 72″<br>S-72″ 15 R. M. 72″ | 61.04 | 31.96 | 98.12 |
| 1921 | Knives (2) Crusher 72″<br>S-72″ 15 R. M. 72″ | 62.77 | 39.5 | 97.84 |

FACTORY No. 16

| Crop | Equipment | Tons Cane per Hour | Dilution | Extraction |
|---|---|---|---|---|
| 1914 | Knives Crusher 72″ 12 R. M. 78″ | 45.61 | 29.33 | 95.57 |
| 1915 | Knives Crusher 72″ 12 R. M. 78″ | 46.61 | 31.40 | 96.14 |
| 1916 | Knives Crusher 72″ S-72″ 12 R. M. 78″ | 42.51 | 37.43 | 96.25 |
| 1917 | Knives Crusher 72″ S-72″ 12 R. M. 78″ | 42.27 | 39.92 | 96.91 |
| 1918 | Knives (2) Crusher 72″ S-72″ 12 R. M. 78″ | 42.04 | 28.88 | 97.40 |
| 1919 | Knives Crusher 72″ S-72″ 12 R. M. 78″ | 41.34 | 36.4 | 97.66 |
| 1920 | Knives Crusher 72″ S-72″ 12 R. M. 78″ | 42.39 | 43.76 | 97.98 |
| 1921 | Knives Crusher 72″ S-72″ 12 R. M. 78″ | 37.16 | 40.55 | 98.05 |

FACTORY No. 13

| Crop | Equipment | Tons Cane per Hour | Dilution | Extraction |
|---|---|---|---|---|
| 1914 | Knives Crusher 78″ 9 R. M. 78″ | 40.02 | 30. 36 | 94.48 |
| 1915 | Knives Crusher 78″ 9 R. M. 78″ | 39.95 | 35.0 | 95.80 |
| 1916 | Knives (2) S-54″ 11 R. M. 78″ | 39.37 | 50.43 | 97.49 |
| 1917 | Knives (2) S-54″ 11 R. M. 78″ | 39.0 | 48.2 | 97.44 |
| 1918 | Knives (2) S-54″ 11 R. M. 78″ | 39.4 | 49.9 | 97.26 |
| 1919 | Knives (2) S-54″ 11 R. M. 78″ | 38.43 | 47.6 | 97.28 |
| 1920 | Knives (2) S-54″ 11 R. M. 78″ | 34.76 | 48.84 | 96.65 |
| 1921 | Knives (2) S-54″ 11 R. M. 78″ | 33.3 | 57.2 | 97.00 |

(1920 and 1921, years of labor strike and shortage factory operated entire year.)

FACTORY No. 6

| Crop | Equipment | Tons Cane per Hour | Dilution | Extraction |
|---|---|---|---|---|
| 1914 | Knives Crusher 72″<br>12 R. M. 78″ | 52.94 | 33.66 | 95.57 |
| 1915 | Knives Crusher 72″<br>S-54″ (part of year) 12 R. M. 78″ | 53.76 | 35.98 | 97.32 |
| 1916 | Knives Crusher 72″<br>S-72″ 12 R. M. 78″ | 55.6 | 40.27 | 97.73 |
| 1917 | Knives (2) Crusher 78″<br>S-72″ 12 R. M. 78″ | 59.6 | 35.18 | 98.56 |
| 1918 | Knives (2) Crusher 78″<br>S-72″ 12 R. M. 78″ | 55.37 | 39.18 | 98.47 |
| 1919 | Knives (2) Crusher 78″<br>S-72″ 12 R. M. 78″ | 48.25 | 50.64 | 98.99 |
| 1920 | Knives (2) Crusher 78″<br>S-72″ 12 R. M. 78″ | 58.08 | 43.93 | 98.92 |
| 1921 | Knives (2) Crusher 78″<br>S-72″ 15 R. M. 78″ | 67.27 | 36.6 | 99.07 |

FACTORY No. 27

| Crop | Equipment | Tons Cane per Hour | Dilution | Extraction |
|---|---|---|---|---|
| 1914 | Knives Crusher 72″<br>9 R. M. 78″ | 36.71 | 30.8 | 94.0 |
| 1915 | Knives Crusher 72″<br>9 R. M. 78″ | 37.84 | 26.6 | 94.3 |
| 1916 | Knives Crusher 72″<br>9 R. M. 78″ | 35.51 | 34.3 | 95.28 |
| 1917 | Knives Crusher 72″<br>9 R. M. 78″ | 34.83 | 40.89 | 96.34 |
| 1918 | Knives Crusher 72″<br>12 R. M. 78″ | 44.19 | 32.4 | 96.51 |
| 1919 | Knives Crusher 72″<br>12 R. M. 78″ | 36.57 | 38.79 | 95.77 |
| 1920 | Knives Crusher 72″<br>S-72 12 R. M. 78″ | 45.15 | 31.86 | 97.25 |
| 1921 | Knives Crusher 78″<br>S-72 12 R. M. 78″ | 45.03 | 27.37 | 97.10 |

FACTORY No. 36

| Crop | Equipment | Tons Cane per Hour | Dilution | Extraction |
|---|---|---|---|---|
| 1914 | Knives 3 R. Cr. 78″ 9 R. M. 78″ | 48.2 | 32.6 | 95.19 |
| 1915 | Knives 3 R. Cr. 78″ 9 R. M. 78″ | 46.5 | 27.9 | 96.10 |
| 1916 | Knives 3 R. Cr. 78″ 9 R. M. 78″ | 43.5 | 24.8 | 95.54 |
| 1917 | Knives S-72″ 12 R. M. 78″ | 58.7 | 31. 3 | 96.56 |
| 1918 | Knives S-72″ 12 R. M. 78″ | 53.7 | 29.0 | 96.60 |
| 1919 | Knives S-72″ 12 R. M. 78″ | 49.64 | 33.8 | 97.32 |
| 1920 | Knives S-72″ 12 R. M. 78″ | 49.56 | 35.3 | 96.94 |
| 1921 | Knives S-72″ 12 R. M. 78″ | 48.33 | 32.1 | 96.83 |

The increased capacity does not show up in the last three years, but in this case this is due to droughts which caused a lack of flume water; the mill did not grind steadily, etc.

## MILLS

The steel rollers which were once thought to solve the problem of the frequently reshelling or renewing of rollers have apparently lost out, but the following letter by Mr. Renton is instructive to show that the Hind-Renton grooving after all has been responsible for the introduction of the deep grooving, now found in many mills as a means to facilitate feeding.

Mr. Renton writes as follows:

One Steel Feed Roller, 34 inches in diameter, 1 inch pitch grooving of 30° angle, was installed in No. 4 mill as a feed roller on December 1, 1914, and the crop started a week later.

This roller has been in continuous use since that date and is now in use completing its eighth crop. It is now 32 inches in diameter and will probably be scrapped this off-season.

No. 4 mill is favorably situated in that the blanket from No. 3 mill of the first mill train passes through long conveyors and is tumbled around considerably before being spread in front of No. 4 mill of the second mill train.

The No. 4 mill with the steel roller has never refused to feed even when returning a considerable quantity of No. 4 expressed juice in front of the fourth mill as well as all of No. 5 expressed juice.

One other new steel roller of ¾ inch pitch, otherwise same as above, is now on hand and was tried out as a feed roller in the sixth mill for the first two weeks of the 1916 crop, but with poor success as it did not feed well. It might be argued that the pitch being ¼ inch less might affect the results, but I am inclined to believe that the size of the fibers in the blanket being short did not give it the necessary gripping effect. Needless to say it was a failure in the sixth mill.

During the last several years conditions have not permitted the experimenting further along this line, but it is my intention to install this new steel feed roller at an early date,

if possible, in some mill ahead of the fifth and then I will be in a position to furnish further information.

Regarding the "Hind-Renton Grooving" of which you make inquiry, I would say that in a measure, it is still with us. In order to feed the necessary tonnage here at Ewa, we departed from the old 1/8 inch pitch standard to 3/8 inch pitch throughout. Later the feed rollers were increased in pitch to 3/4 inch with still better results in capacity. We are now going back to the fine grooving in top and back rolls, but retaining the 3/4 inch pitch feed rolls as well as juice grooves in the feed and back rolls. I believe this last combination is being adopted by all factories grinding large tonnage of cane.

The Hind-Renton grooving is responsible for the introduction of the coarse grooving.

**Mill-cheeks:** There are still undesirable features in the present design of the mill cheeks, and particularly in the fact that only a small margin of roller wear is possible.

Some years ago 33 inch diameter rollers were used, or recommended for use, to take the place of the regular 32 inch rollers. Perhaps some of the engineers present can give us information as to the success or failure of this experiment.

**Intermediate carriers:** A new departure in this has been the introduction of the Meinecke chute, the construction of which is of course now known to every one, and as far as I know it has given full satisfaction wherever installed.

**Mill beds and cush-cush:** Our problem of disposing of the cush-cush is still with us in the mills that have the old style mill beds. When we speak of this cush-cush we mean the coarser material. The finer particles, which come under the name of suspended matter, are now receiving more and more attention since the general opinion now prevails that it is these fine particles which cause so much of the stickiness and gummyness of our after products.

Mr. H. C. Welle, Chief Chemist for the California & Hawaiian Sugar Refinery Corporation, in a recent report on the qualities of raw sugars, writes:

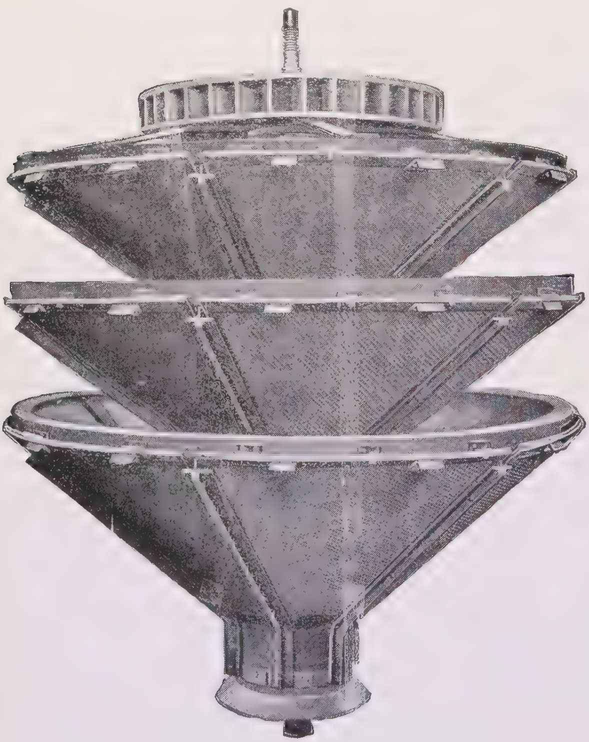
Another phase that possibly may be of greater interest to the refiner is the probability that the extensive milling disintegrates the fiber of the cane to such a degree as to make it much more difficult to remove the so called "cush-cush" by means of screens, than would be the case with more moderate milling.

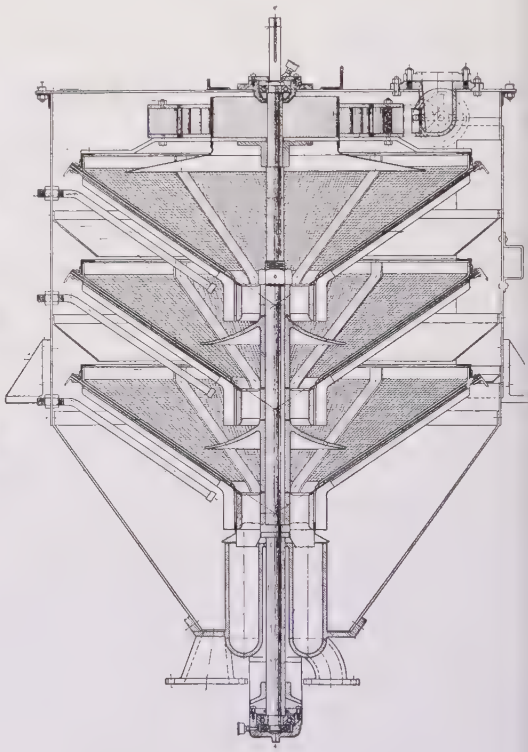
It is purely surmise, but based on various definite observations, that this extremely finely divided solid material in suspension, when treated with lime at the high temperature of the tubular heaters, is changed or partially changed into a gummy material such as dextran.

In most cases the low grade products were noted to be very gummy indeed, and it may be that this theory may partly account for such a fact.

A device designed by Mr. S. S. Peck is now in operation in one of the factories on this island. Another screening device has been mentioned in the sugar journals and is of the following description:

A test of the Carter Automatic Juice Strainer manufactured by the Horton-Brown Corporation, 149 Broadway, New York City, was recently made in connection with the straining of cold cane juice, and some interesting data secured as a result. One of these machines was installed by the West Indian Sugar Finance Corporation at its Central Consuelo in the Dominion Republic for the purpose of operating on the cold juice. Since 1916 this factory has been using a Carter Automatic Juice Strainer on hot juice with great success, handling the entire output of the factory with a grinding capacity of 2,800 tons of cane per day.





This season it was decided to try one of these machines on the cold juice. The test was successful. One hundred thousand bags of sugar have been made to date.

The juice, for convenience in testing out this machine on cold products, is weighed and limed first. The common receiving tank from the scales is used as the supply for the strainer which is situated on the same floor as the juice heaters. The juice flows by gravity from the supply tank, 8 feet 5 inches above the inlet nozzle on the strainer, driving the machine 40 r. p. m.

The suspended matter removed from the juice flows by gravity through the mud pipe beneath the strainer, from which it is pumped through the heaters.

The suspended matter removed from the juice flows by gravity through the mud pipe at the bottom of the strainer to the mud canal under the defecators, with the volume of a one-inch pipe of juice escaping with it. This small volume of unstrained juice passes over the screen surface and keeps them clean, at the same time conveying the separated matter wherever desired.

With this arrangement, the bagacillo passing through the mill strainer is prevented from being heated, or passing into the defecators or evaporators. Through the mud tanks, the solid matter removed by the cold strainer reaches the filter presses.

The sizing given the bagacillo after passing the final screen and the cold strainer, which has an opening of 0.0115 inch, is believed to be large enough to make a porus filtering material, which would allow the removed bagacillo to be returned to the mills.

The mill juice strainer is 12 mesh brass punched plate with 144 holes per square inch; size of opening 0.053 inch.

The Carter strainer has three sets of twilled monel metal wire cloth screens as follows: first screen, 20 mesh, holes per square inch 400, size opening .0220 inch; second screen 30 mesh, holes 900, size opening .0163 inch; third screen, 40 mesh, holes per square inch 1600, size opening .0115 inch.

Upward of 17,000 pounds of bagacillo is removed from the cold juice each 24 hours from the juice of 2800 tons of cane. Before straining the cold juice, 2500 pounds of bagacillo was being removed from the clarified juice each 24 hours on average cane, by the hot juice strainer, and much more on burnt cane.

Since installing the cold machine, the bagacillc has decreased from 2,500 pounds in the hot juice, to less than 500 pounds in 24 hours.

The percentage of mud from the defecators has decreased, much more clear juice is recovered, and the juice settles more readily. The general clarification is improved and the heaters, defecators, and evaporators are free from the scale and deposits of former years. The fabrication department can handle more juice than in former times.

The following is an extract from a letter received from The Horton-Brown Corporation regarding this strainer:

The foregoing represents the latest method for handling raw juice and takes the place of the method described on the insert in the booklet. From this you will note that the raw juice is being strained before it is limed.

A number of factories do not have sufficient head room to use a gravity drive and for these conditions different methods for operating the Carter Strainer have been developed. One method consists of a mechanical drive which is placed on the top of the strainer. This drive is made up of a bevel pinion which is fitted to the central shaft extending from the top of the strainer. The power is taken from a bevel gear mounted on a shaft running parallel to the top of the machine. On the outside end of the shaft are placed either tight and loose pulleys, to take a belt from the line shaft in the factory, or a single pulley, to take a belt from a motor.

With the above outlines, we believe you will be able to form a good idea of just what the Carter Juice Strainer may be expected to accomplish. We would like, however, for you to keep in mind that the Carter Strainer is a STRAINER and **not** a filter. We find that a great many people endeavor to make a filter out of a strainer, and by so doing spoil any good results that might otherwise be obtained.

In last year's report of this committee and on several other occasions the question was brought up: "How much of this high extraction sugar do we get in the bags?", and therefore any definite data are always taken up with considerable interest. The following is a report by J. Lewis Renton, mill superintendent, on the recent experiences at Ewa:

Unloader chain on Gregg Unloader was changed to heavier link chain of a different make, thereby reducing the delay due to the unloader from four hours per week to less than one-half hour per week stoppages for that station. The original chain was not only lighter in construction, but the material was very poor and gave trouble even when new, particularly the last new lot purchased.

Meinecke Intermediate Carriers were installed in the second nine roller mill train, or "B Mill" during the period February 14 to May 20, 1922, when this mill was shut down for repairs. Mr. Purcell, the Chief Engineer, reports that "During the thirteen weeks the new Meinecke Intermediate Carriers have been in operation no delays for

repairs or adjustments have been necessary, though a little extra attention was necessary for the first few days. Sunday work on scraper upkeep about the same as formerly.''

Juice pans of an improved type were installed in this ''B Mill'' train during this same shut down period. These juice pans are of the deep steep-sloping side pattern being 45% slope under the back roll and sides, and 30% slope under the feed roller; the idea being that there is so much liquid expressed by the feed roller that the slope under the feed roller will be washed clean of any accumulation of cush-cush and the remaining slopes so steep that cush-cush cannot lodge on same, keeping the entire pan as sanitary as possible and eliminating any pockets or accumulations where souring might take place. Would recommend making slope under back roller still steeper than 45%. This installation is a big improvement over the juice pans previously used, and does away with one man keeping the juice pans clean.

Mr. Orth, the Chief Chemist, reports ''There is considerably less difference in purities between crusher juice and normal juice, mixed juice and syrup in 1922 than in 1921 and 1919. 1921 may be considered abnormal but 1919 is regarded here as a normal year. We did have about 15% less dilution on an average so far this season and this may have some influence on the purities, but I am inclined to give most credit for the improvement to the cleaner conditions around the mill. That the differences in the figures during the 18-roller mill period this year are not larger than when grinding with a 9-roller mill is, in my opinion, in a great measure due to the new conveyors and juice pans, which can be kept clean easily.''

| | 1922 | | 1921 | 1919 |
|---|---|---|---|---|
| | 9 RM Period | 18 RM Period | 18 RM Period | 18 RM Period |
| Crusher juice app. pur. | 87.62 | 86.56 | 84.15 | 86.30 |
| Normal juice | 84.04 | 83.36 | 78.86 | 81.83 |
| Mixed juice | 84.70 | 83.82 | 79.37 | 82.61 |
| Syrup | 86.16 | 85.19 | 80.97 | 84.28 |
| Cr. J. nor. juice | 3.58 | 3.20 | 5.29 | 4.47 |
| Cr. J. mix. juice | 2.92 | 2.74 | 4.78 | 3.65 |
| Cr. J. syrup | 1.46 | 1.37 | 3.18 | 2.02 |

During the foregoing forced shut down of ''B Mill'', the second 9-roller mill train, ''A Mill'', continued grinding from February 14 to May 20, 1922. The equipment of ''A Mill'' consists of two 72 knife sets, two roller crusher 32"x78", and 9-roller mill 34"x78".

Records were kept on cost and recoveries. It was found that it cost very close to $1.00 a ton of sugar manufactured to operate the second mill train or ''B Mill'' and that the extra 4% higher extraction more than paid for this extra expense.

The formula used to figure out the increased return in dollars of an 18-roller mill above what would have been received if operating as a 9-roller mill was:

$$S = X\,Y - (A + B)$$

S = Increased return in dollars 18-roller mill over 9-roller mill.
X = Tons sugar recovered due to higher extraction.
Y = Dollars received per ton sugar.
A = Extra cost of manufacturing.
B = Extra cost of marketing X tons of sugar.

From the above the following table was computed for varying prices of sugar and varying syrup purities:

INCREASE RETURN IN DOLLARS OF 18-ROLLER MILL OVER 9-ROLLER MILL.

ASSUME 285,715 tons cane per crop.
14% Sucrose in cane (about 13.7 Pol'n.).
98% Extraction with 18-roller Mill.
94% Extraction with 9-roller Mill.

| Price received for sugar. Dollars per Ton. | PURITY OF SYRUP | | | | |
|---|---|---|---|---|---|
| | 70 | 75 | 80 | 85 | 90 |
| $110.00 | $87,604. | $94,315. | $99,758. | $105,004. | $109,339. |
| 100.00 | 75,826. | 81,640. | 86,342. | 90,886. | 94,636. |
| 90.00 | 64,048. | 68,965. | 72,926. | 76,768. | 79,933. |
| 80.00 | 52,270. | 56,290. | 59,510. | 62,650. | 65,230. |

Mr. Nolan, the Sugar Boiler, states that "during the 9-roller period, one crystallizer was filled for each 63.9 tons of sugar bagged, and during the 18-roller mill period, one crystallizer was filled for each 57 tons of sugar bagged. He also reports that during the 9-roller mill period the evaporators were cleaner, requiring only one gang of five men for each Sunday, as compared to two or three gangs of five men each when running an 18-roller mill. He further reports that the boiling of both first and second sugars was easier during the 9-roller mill period. No noticeable change was observed in clarification when we changed from a 9-roller to an 18-roller mill or in the mud press station."

The tons sugar recovered due to higher extraction was computed from data obtained during the 9-roller mill period from February 14 to May 20, 1922, as compared with the 18-roller mill period from May 20 to July 22, 1922.

The gravity purity of the waste molasses was the same in both cases, namely 37.12. The tons of waste molasses per ton sucrose in sugar for the 9-roller mill period was 0.255 and for the 18-roller mill 0.236. This slight difference may be an error in estimating molasses in stock and, for this experiment, may be considered the same.

Sucrose balances for the two periods mentioned above are enclosed for those interested.

## SUCROSE BALANCE

| | 9-roller mill period February 14 to May 20, 1922. | | | | | | 18-roller mill period May 20 to July 22, 1922. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Tons | % Sucrose | Sucrose % Cane | Sucrose % Sucr. in Cane | Sucr. % Sucr. in Mix. Juice | Tons Sucrose | Tons | % Sucrose | Sucrose % Cane | Sucrose % Sucr. in Cane | Sucr. % Sucr. in Mix. Juice | Tons Sucrose |
| Cane | 100,791.54 | 13.34 | .... | 100 | .... | 13,370.59 | 62,981.79 | 14.26 | 14.26 | 100 | .... | 8,980.39 |
| Mixed juice | 112,469.35 | 11.18 | 12.55 | 94.07 | 100 | 12,578.06 | 72,020.73 | 12.22 | 13.97 | 97.98 | 100 | 8,799.20 |
| Bagasse | 24,865.02 | 3.19 | 0.79 | 5.93 | .... | 792.53 | 13,069.04 | 1.39 | 0.29 | 2.02 | .... | 181.19 |
| Press cake | 1,946.62 | 1.31 | 0.02 | 0.19 | 0.21 | 25.47 | 1,535.31 | 0.91 | 0.02 | 0.16 | 0.16 | 14.00 |
| Waste molasses | 2,941.12 | 32.34 | 0.95 | 7.11 | 7.56 | 951.11 | 1,895.98 | 33.27 | 1.00 | 7.02 | 7.17 | 630.82 |
| Undetermined | ........ | .... | 0.07 | 0.50 | 0.53 | 67.08 | ....... | .... | 0.17 | 0.17 | 1.19 | 105.20 |
| Total losses | ........ | .... | 1.83 | 13.73 | 8.30 | 1,836.19 | ....... | .... | 1.48 | 10.37 | 8.52 | 931.21 |
| Commercial sugar, recovery | 11,866.07 | 97.20 | 11.51 | 86.27 | 91.70 | 11,534.40 | 8,277.53 | 97.24 | 12.78 | 89.63 | 91.48 | 8,049.18 |
| Commercial sugar, to date, Gr. Pur. | | | | | | 98.59 | | | | | | 98.75 |
| Syrup to date, Gr. Pur. | | | | | | 86.89 | | | | | | 86.17 |
| Waste molasses to date, Gr. Pur. | | | | | | 37.12 | | | | | | 37.12 |
| Theoret. B. H. recovery | $\frac{98.59\ (86.89-37.12)}{86.89\ (98.59-37.12)}$ | | | | | 91.87 | | | | | | 91.21 |
| Theoret. molasses loss | | | | | | 8.13 | | | | | | 8.79 |
| Act. % theoret. B. H. recovery | (91.70 × 100) : 91.87 | | | | | 99.82 | | | | | | 100.30 |
| Act. % theoret. molasses loss | | | | | | 92.99 | | | | | | 81.57 |
| Sucrose accounted for per 100 obtainable sucrose | 11,534.40:(12,578.06—25.47) × 91.87 | | | | | 100.01 | 8049.18 (8799.20—14.00) × 91.21 | | | | | 100.45 |
| Based on normal juice plus (Gr. Pur. Syr.—Gr. Pur. Mix. J.) Factory efficiency number | $\frac{86.27 \times 100}{91.39}$ | | | | | 94.40 | $\frac{89.63 \times 100}{91.09}$ | | | | | 98.40 |
| Based on 100 extraction and 35 gr. pur. waste molasses | Factory efficiency 1921 | | | | | 94.23 | | | | | | |

| Comparison of | 9-Roller Period and | 18-Roller Period |
|---|---|---|
| Theoretical boiling house recovery* | 91.85 | 91.28 |
| Extraction | 94.07 | 97.98 |
| Actual boiling house recovery | 91.70 | 92.05 |
| Total recovery | 86.26 | 90.19 |
| Gain in extraction | .... | 3.91 |
| Gain in total recovery | .... | 3.93 |

*Sugar purities were equalized (98.62). Molasses purities happened to be alike, so that the difference of 0.57 is due *only* to difference in syrup purities. This 0.57 is added to the actual boiling house recovery in the 18-roller period to make the figures comparable with the 9-roller period.

Mr. Herbert Walker, Superintendent of Pioneer Mill Company, adds the following:

The new equipment put in at Pioneer for the 1922 crop was, two calandria pans, 1400 cubic feet, 1700 square feet h. s. each, a separate juice strainer and cush-cush returned for the fifth mill, and a Meinecke type intermediate conveyor between the first and second mills.

The new pans have been a great help to us in several respects. The extra heating surface allows us to boil entirely with exhaust steam except for about half an hour when boiling down. Dividing the number one sugar pans in three units instead of two keeps at least one pan going all the time and helps balance the demand for steam, so that we are able to utilize all the exhaust from the mill engines and the turbine even when generating more electric power than the mill needs. The exhaust pressure has been reduced to between 0 and 4 pounds. The installation of these pans seems to have been the finishing touch needed to complete our steam economy program, and for the first time on record we have gone through a season without burning extra fuel. I think the new evaporator put in for 1921 was probably needed more than the pans, but the combination was necessary to get the best results. The additional equipment released for low grade work the large pan formerly used for commercial sugar, and, given more time for boiling, the low grade grain was increased to an average of .3 to .5 mm., about double the former size, which made it possible to dry all our massecuite without dilution or heat and resulted in a much lower waste molasses purity. The shipping sugar grain was also increased in size to about 10% "total small". I have not heard whether or not this was considered an improvement.

The separate cush-cush returning system for the last mill helped to reduce the maceration needed without sacrificing extraction. It also reduced very slightly the amount of suspended solids in the mixed juice.

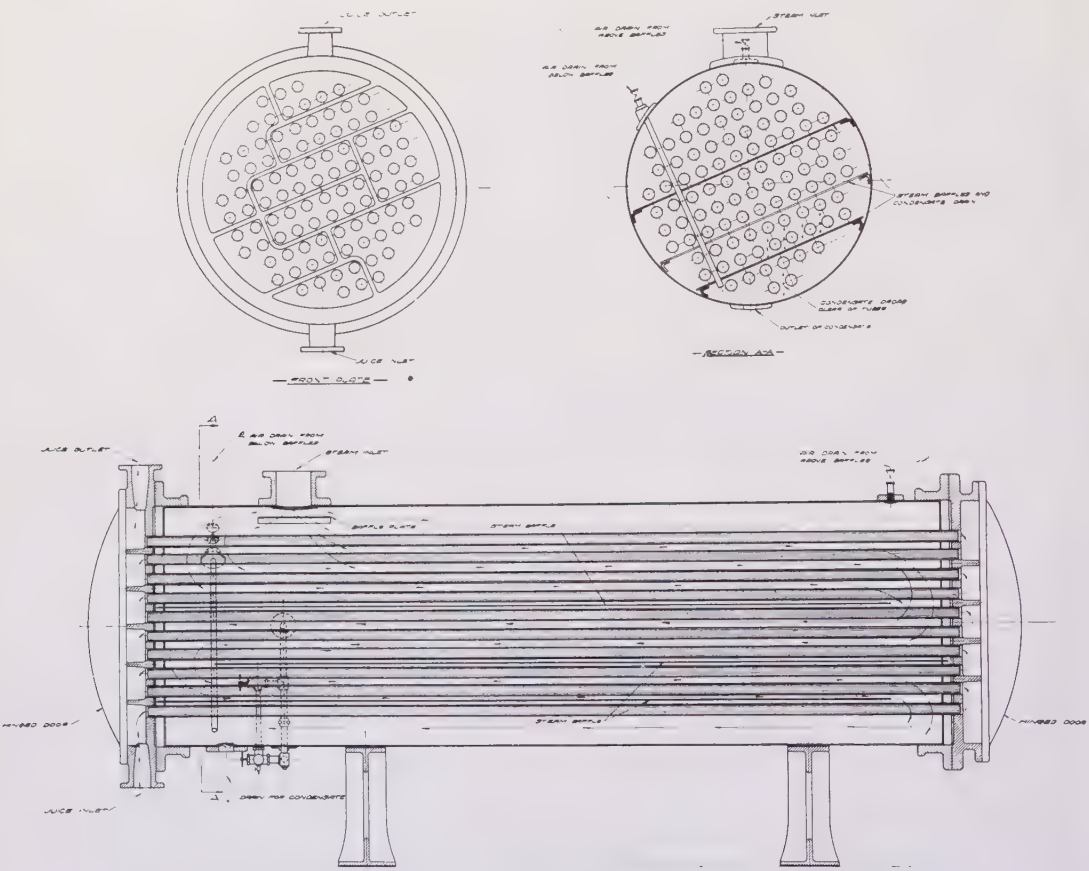
In my report to you last year I suggested that experiments be carried out to determine how much sugar actually could be obtained from last mill juice under conditions of high extraction, high ash and low glucose. Results obtained here during the 1922 crop indicate that a low glucose—ash ratio does not of itself prevent crystallization down to a fairly low purity molasses. During a period of several weeks our waste molasses averaged less than 34 gravity purity and contained more ash than glucose.

## JUICE HEATERS.

Mr. E. Kopke of the Honolulu Iron Works, who is the author of several interesting articles and studies on this subject, described a newly designed heater in a report last year to the H. S. P. A. Because the Mill Engineers' Association has had no regular meeting during the last two years, this information might have escaped the attention of many and is therefore incorporated in this report.

In practice is it found that the maximum capacity of this type of heater may be taken at 60 pounds of juice per hour per square foot of heating surface, when the juice velocity through the tubes is about 6 feet per second and the steam pressure on the body about 4 pounds per square inch and the juice temperature rises from 80° to 212° F.

The capacity of any heater or what is the same thing, a surface condensor, depends upon:

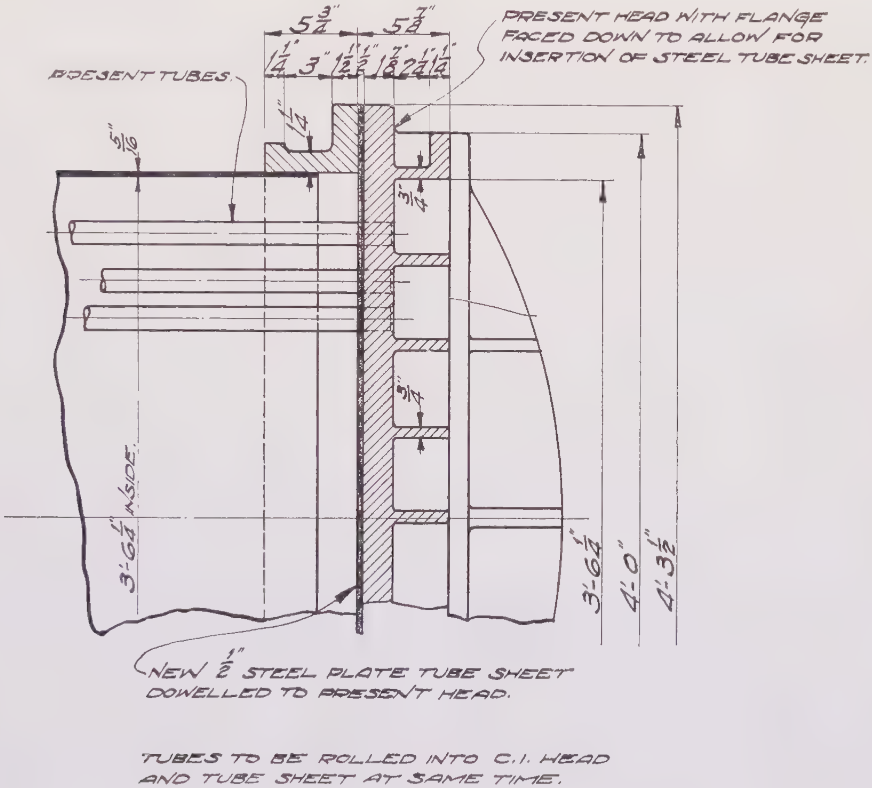


GENERAL ARRANGEMENT
OF
SPECIAL INCLINED BAFFLE JUICE HEATER

1. The actual temperature difference between the steam and juice.
2. The conductibility of the dividing partition (heating surface).
3. The voidance of the condensate that forms on the heating surface.
4. The velocity with which the juice flows along the heating surface on the other side.

The improvements of the juice heater under consideration, made by the Honolulu Iron Works, are diagrammatically illustrated herewith. It accomplishes two things: Voiding the condensate as it forms over the tubes, and bringing about a decided steam velocity along the tubes. The direction of the steam flow is practically counter-current to the flow of the juice.

Referring to the cuts, the front plate shows the lay out of the tubes. The rows of tubes are slanting. Section A A shows the arrangement of tubes as shown in the front plate and the steam baffle, condensate drain plates, bottom and top air vent, also the steam inlet nozzle and condensate outlet. Fig. H is a diagrammatical length section of the heater.




The steam enters through the upper nozzle in the comparatively large space of the cell above the upper slanting steam baffle or condensate drain plate. The plate is placed close against the head nearest the steam inlet nozzle, but leaves an open space between it and the opposite head. The steam is induced to flow, as indicated by the arrows, along the upper bank of tubes, and to turn at the end of the plate down into the next lower space. This flowing to and fro of the steam is repeated as often as there are plates in the cell until it is condensed and flows off through the condensate outlet.

The comparatively high steam velocity induced by the partitioning with baffle plates aids the separation of condensate from the tubes. The drip from the upper bank of tubes falls on to the slanting plate, and is delivered to the shell of the heater away from the next lower one. Between the edge of the plate and the shell is ample space to allow the condensate to flow through. The same occurs, of course, in the rest of the compartments until the outlet is reached.

Another important feature embodied in this design is that the baffle plates are placed so that the cross sections of the different compartments decrease in area from the top down. The steam is reduced in volume through loss of heat from one compartment to the next, but an approximately even steam velocity is maintained.

The sum of these changes in design from the old one has invariably increased the capacity of the heater per square foot heating surface 100%. This has been shown in numerous installations in Cuba, and also in the first one here in Hawaii.

In recent years quite a few of the juice heater juice heads used to crack, as well as the doors. Whether this breaking is due to faulty design or to careless operating has been the subject of dispute many times.

The sketch submitted here, and contributed by Mr. A. Ewart, shows a new method of repair or rather a way to eliminate the danger of juice getting into the steam space. A one-half inch steel plate is placed right back of the tube-head which latter part must first be planed and the steel plate made a close fit.

Still another type of juice heater is the one illustrated on next page and designed by Mr. T. Terry, who writes as follows:

The chief points of attraction in this design of juice heater are:

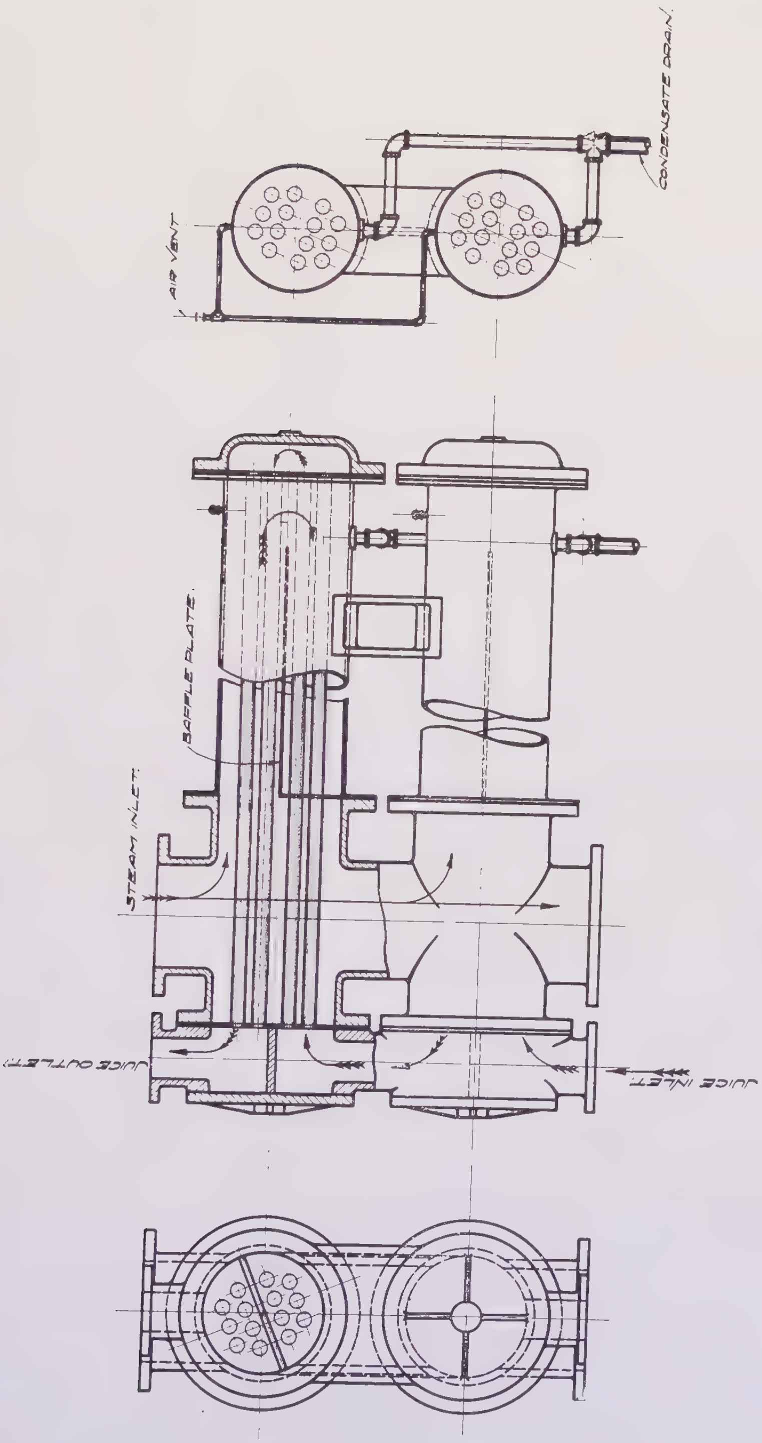
1. The counterflow principle between the juice in the tubes and the steam outside is 100%.

2. The condensate is drained rapidly from each group of tubes and is thus eliminated from interfering with the efficiency of other tubes.

3. All tubes are equally supplied with the available steam directly from the supply manifold.

4. The square feet of heating surface can be increased when necessary by purchasing extra sections.

5. The covers and heads are not subject to breakage and yet can be removed easily for cleaning.




PROPOSED JUICE HEATER.

SCALE 1½"=1'-0"

OCT. 9-1922.

## CLARIFICATION.

Ever since the news passed around that two of the largest factories had decided to adopt the Thomas and Petree process, a keen interest is felt in the exact construction and mode of operating the Dorr Clarifier which forms a part of the equipment.

The cut herewith represents a clarifier 20 feet in diameter and is rated to take the juice of 2,000 tons of cane per day.

A circular tank "A" 20 feet in diameter by 14 feet high, has a conical bottom. "B" is firmly bedded in concrete. The tank is divided into four compartments, C—1, C—2, C—3, C—4. The divisions are made by circular conical plates "D" fastened tightly to the periphery of the tank "A." The slope of the cone towards the center is the same as that of the bottom.

On the upper division plate "D" rests the feed well "E" about 8 feet in diameter by 2 feet 6 inches deep. The feed well "E" is provided with a juice inlet pipe "F" with revolving skimming paddles "G" and a discharge outlet "H" to a launder "I" for conveying skimmings.

In the center of the tank is placed a vertical shaft "J" which revolves once in six minutes. On this shaft are fastened arms "K" which carry scrapers "L" that touch the conical plates "D." The feed well "E" has a central tube "M" reaching into the compartment below it and in a like way from subsequent compartments to the next below.

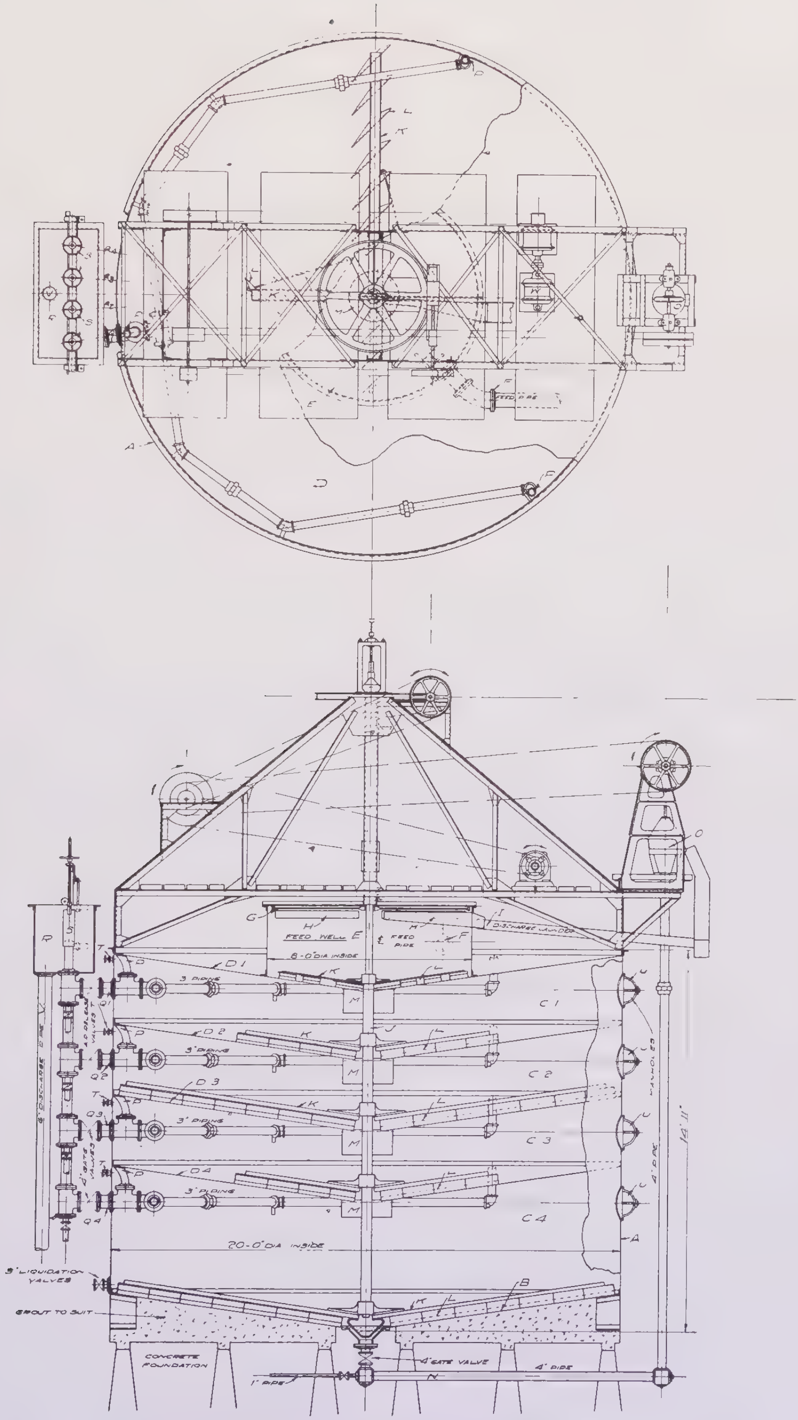
The center of the tank bottom is connected to a 4 inch pipe "N" which conducts by the suction of the pump "O" the mud to the mudpresses. The clear juice is drawn from each compartment at three equally spaced points "P" at the highest part of the compartment near the periphery of the tank.

The clear juice pipes "Q" from each of the compartments are connected separately outside the tank to an overflow box "R." The top edge of this box is level with the feed well overflow. The height of overflow can be regulated separately by screw and handwheel operated sleeves "S" and the rate of flow increased or decreased by this adjustment. Air vents "T" and manholes "U" with covers are provided.

The following contribution was received from Mr. W. L. McCleery, Assistant Sugar Technologist of the H. S. P. A. Experiment Station:

My experience with the Dorr Clarifier, or Dorr Thickner as it is called on the mainland, was in its use in beet sugar work in the Steffens molasses desugarizing process. It was used as a thickner in concentrating the precipitate in hot waste. Approximately 80% of the volume of material fed to the Dorr overflowed as an absolutely clean liquid, and the remaining 20% was a mud drawn off at the bottom which was then filtered on vacuum filters.

The apparatus is simple in construction, and consists of an insulated and closed steel tank, equipped with several steel trays which form settling compartments connected with each other by central openings. There is a very slow moving vertical shaft arranged with arms to sweep the surface of each tray. The shaft revolves once in about seven or eight minutes so that the power required to drive the mechanism is very small. There is




GENERAL ARRANGEMENT OF 'DORR' CLARIFIER
FOUR COMPARTMENT TYPE.
SCALE 1/4"=1 FOOT OCTOBER 30, 1920

a so called "loading well" attached to the cover, in which skimmers, operated by the central shaft, remove all foam. Our overflow was always equal to the finest filtration when the material was heated correctly to give a good settling rate. The temperature loss was not over 3° Centigrade. It does not require a skilled man to operate the installation. In fact, when once adjusted and with regular running very little attention is required.

It is my opinion that this clarifier would be very satisfactory when operating on cane juices. The floor space occupied is much less than required with the usual form of settling tanks used in these Islands. The time that the material is in process should be much less, and the temperature loss is very small compared with that of intermittant settling. The moving scrapers in the bottoms of the trays should make the apparatus self cleaning, which is an advantage over our present operations. The Dorr installations, however, should be sufficiently large to take care of slow settling juices, as with the present intermittant form of settling, if a small batch of poor settling juice is encountered the tanks containing the poor settling juice can be held out of their turn, if necessary, without slowing down the factory to a very great extent. The Dorr therefore does not have this flexibility that intermittant settlers have.

With good settling juices the Dorr should prove very satisfactory. With poor juices chances will have to be taken on having sufficient settling capacity. It is possible that the latter juices may work better in the Dorr than in the usual settlers, because the Dorr is very well insulated, not only to conserve heat, but to prevent the setting up of convection currents in the juice due to unequal temperatures. There must be a large amount of these convection currents set up in many of our intermittant tanks, due to the small amount of insulation used and lack of covers. This is a great detriment to efficient settling of juices which have a tendency to settle poorly.

In connection with fine juice-screens to remove suspended matter from the clarified juice, Mr. Raymond Elliott, Chemist of the Paauhau Sugar Company, writes:

During the early part of the 1922 crop, the Gartley Bagasse Juice Filters were discarded. It was thought that a revolving screen would do the work just as well and at the same time release two men for field work.

The revolving screen installed was 30 inches in diameter by 54 inches long, having 35.3 square feet screening area. The screen was 50 mesh, brass woven wire. After several days the screen began to crack and tear, due to the expansion and contraction of the heat. After replacing, the same thing happened again and a flat screen was installed. This screen is a 50 mesh Monel metal woven wire, 54 inches wide by 48 inches long, giving 18 square feet screening area, and is backed by an old mill juice screen. The angle measured from the horizontal is 13.5 degrees.

The juice from the clarifiers flows to an iron box, where the front is cut away, so as to distribute the juice evenly over the surface. The screenings are raked off with a soft wooden hoe, into a round flume, connected with running water, which flushes it to the mud tanks. The man who tends the evaporator, also looks after the screen. The flat screen has not given any trouble and is just as good as the day it was put in.

The following tabulation, taken from data supplied by the Crockett refinery, shows the progress made in the attempt to reduce the quantity of suspended solids in the raw sugar:

| | 1916 | 1917 | 1918 | 1919 | 1920 | 1921 |
|---|---|---|---|---|---|---|
| Hawaiian Commercial & Sugar Co......... | .060 | .033 | .041 | .051 | .035 | .024 |
| Maui Agricultural Co.................... | .070 | .052 | .090 | .107 | .075 | .073 |
| Kahuku Plantation Co.................. | .078 | .042 | .056 | .053 | .070 | .051 |
| Hutchinson Sugar Plantation Co.......... | .047 | .040 | .041 | .065 | .047 | .046 |
| McBryde . . ........................... | .037 | .035 | .054 | .076 | .068 | .064 |
| Wailuku . . ........................... | .049 | .043 | .076 | .110 | .113 | .132 |
| Hawaiian Agricultural Co............... | .050 | .050 | .079 | .087 | .065 | .052 |
| Onomea . . ........................... | .051 | .045 | .047 | .061 | .052 | .040 |
| Pepeekeo . . .......................... | .040 | .043 | .031 | .058 | .046 | .036 |
| Honomu . . ........................... | .041 | .035 | .040 | .045 | .041 | .035 |
| Hawaii Mill .......................... | .... | .031 | .033 | .042 | .037 | .034 |
| Kaiwiki Sugar Co....................... | .040 | .043 | .064 | .047 | .045 | .064 |
| Hamakua Mill Co........................ | .094 | .061 | .147 | .117 | .119 | .098 |
| Laupahoehoe Sugar Co.................. | .138 | .108 | .157 | .085 | .062 | .069 |
| Waiakea Mill Co........................ | .075 | .056 | .086 | .070 | .053 | .036 |
| Union Mill .......................... | .... | .206 | .205 | .243 | .196 | .113 |
| Olaa Sugar Co......................... | .113 | .097 | .097 | .105 | .074 | .086 |
| Oahu Sugar Co......................... | .049 | .047 | .065 | .111 | .065 | .041 |
| Kipahulu . ........................... | .... | .061 | .146 | .134 | .160 | .... |
| Pioneer . . ........................... | .059 | .044 | .038 | .064 | .055 | .048 |
| Koloa . . ............................ | .... | .053 | .061 | .071 | .064 | .064 |
| Makee . . ............................ | .073 | .060 | .057 | .073 | .044 | .047 |
| Ewa Plantation Co...................... | .075 | .045 | .068 | .072 | .045 | .043 |
| Kohala . . ........................... | .061 | .058 | .056 | .060 | .... | .046 |
| Honokaa . . .......................... | .054 | .052 | .143 | .079 | .096 | .116 |
| Hawi . . ............................. | .049 | .049 | .038 | .076 | .058 | .048 |

## ENTRAINMENT.

Quite a few factories are again experimenting with different devices to reduce juice entrainment.

Mr. E. Kopke writes as follows in a recent publication:

Entrainment may be caused (a) by splashing, (b) by finely divided particles of the sugar-containing-mass being carried along with vapors (this is called "vesicular transference") and (c) by "creeping," (a film of juice having been deposited on the sides of the cell or vapor-pipe is induced to creep in direction of the flow of vapors and finally becomes lost in the condenser), or by (d) drain pipe from save-all short circuiting into vapor space of cell instead of into the body of juice in cell or through a U-tube.

Conditions favorable to splashing are long tubes of small diameter, maximum height of liquor to top of upper tube sheet but not over it, and high vacuum in last cell and great temperature difference between vapor of last and second last cell.

Mr. A. Fries, Chemist of Honokaa Sugar Company, reports as follows:

The separators or save-alls used in former years in the vapor pipes of evaporators had as their principal feature the sudden increase in volume, thereby causing a sudden reduction in vapor velocity and bringing about the bursting of the bubbles, which contain vapor and sugar. In connection with this reduction in vapor velocity, baffle plates were used

and so arranged as to cause a reversal of the vapor current and the throwing of the bubbles against the plates, thereby releasing the vapor and allowing the liquid to drop back.

A design of separator extensively used in the islands for some years is a type made of a series of short tubes inserted in three or four sheets. The whole is placed in an enlarged section of the vapor pipe, in which case the vapors generally pass the tubes in a horizontal direction, or into the dome of the evaporator cell, when the vapor traverse the tubes vertically.

The difference between this type of save-all, known as the "Stillman" and the above is that there is no sudden reduction in vapor velocity, as the area of the tubes is only slightly larger than the area of the vapor pipe. Not having this principal feature of the old style save-all may account for the fact that in some instances the Stillman has not been sufficient to stop entrainment in evaporators. In one factory using Lillie Evaporators, the Stillman traps reduced but did not eliminate the loss of sugar through entrainment. It was said, however, that the design, being one of the first in the islands, was faulty. Another factory, using a Stillman of the vertical type, in connection with a standard evaporator, showed considerable entrainment, which was completely stopped after putting in a six-foot belt and installing baffle plates inside the vapor space of the last cell. During the 1921 crop there was quite a loss of sugar through entrainment of the Honokaa evaporator. To remedy this the old baffle plates were removed and replaced during the off season by a Stillman trap, placed inside the last cell above the top flange. The entrainment from the start was much greater than in the previous year, amounting at times to a loss of 1000 to 1500 pounds of sugar per 24 hours. As there was nothing wrong with the evaporator or the method of operating it, the fault could only be with the newly installed Stillman. This was confirmed when it was found that the difference in vacuum above and below the trap was three-fourths of an inch.

To stop further loss as quickly as possible wooden baffle plates, as a temporary arrangement, were installed in the early part of the season and accomplishing what was desired, were kept in use throughout the rest of the crop. There is nothing new about the arrangement of these baffles, Mr. Orth introduced it with good success at Koloa and later the Makaweli Factory installed the same system, thereby completely stopping all entrainment. After placing the wooden baffles in the Honokaa evaporator the entrainment loss was reduced to a reasonable figure, when running at the rate of forty tons of cane per hour, while at a lower rate of evaporation no sugar could be found in the condenser water. It is expected that after replacing the wood by iron that the entrainment will be eliminated under any condition of evaporation. It may reasonably be concluded from the above that a Stillman trap is not in every instance capable of stopping entrainment, in fact it may increase it as the experience here has shown.

The following data refer to the detail of design:

| | |
|---|---|
| Diameter of cell | 8′ 7″ |
| Top tube plate to top flange | 8′ 4″ |
| Diameter vapor pipe | 26″ |
| Stillman trap, number of tubes in 1 plate | 160 |
| Diameter of each tube | 2¼″ |
| Total area of tubes | 635 sq. in. |
| Area of vapor pipe | 520 sq. in. |

Mr. McAllep in his report after the yearly inspection of the factory comments as follows:

"Previous to this season the old baffle plates were removed from the last cell of the evaporator and a Stillman trap installed. Frequent tests indicated that the entrainment was increased rather than reduced. Early in the season a wooden baffle was installed under this trap reducing the entrainment to a small amount, though, according to these tests, not entirely stopping it. Some three weeks prior to my visit the entrainment started to increase. On Sunday the wooden baffles which had shrunk at some places

were repaired and on Monday a test by me failed to show any loss through entrainment. On this day, however, the evaporator was operated at a somewhat lower capacity than usual. According to calculations made from the laboratory figures, 28.5 tons of water were evaporated per hour against an average for the preceding week of 31.4. Some entrainment might still take place at the higher rate of evaporation even though this test was negative.

"I was very much interested in the failure of the Stillman trap to stop entrainment as in all but two or three cases that have come under his notice, this style of trap has been very efficient. A possible explanation lies in the throttling effect of this installation. According to figures given me the tubes have an area of 4.4 sq. ft. Mercury gauges on the last body below and above this trap indicated respectively, 24.5″ and 25.25″ vacuum, a difference of ¾″. As this factory is 460 feet above sea level, a correction of approximately half an inch must be added to these figures, making them 25″ and 25.75″. With an evaporation of 30 tons of water per hour, some 8.4 tons would be evaporated in the last body. Under these conditions the vapor would enter this trap with a velocity of slightly over 150 feet per second and leave it at 180 feet. The temperature of saturated steam at these two points would be 133 and 127 degrees. It appears probable that such instantaneous decrease in the boiling point would cause drops of juice carried along with the vapor to boil with almost explosive force, and that the resulting spray would be carried through the trap with the current of vapor."

Others seem to have had about similar experiences with the Stillman trap. Mr. Elliott tried to determine the exact quantity sugar loss and gives the following description of his test:

September 18th to 23rd inclusive, a test was run on the entrainment indicator of the fourth effect to ascertain the amount of syrup entrained. The syrup was weighed, composited and analyzed every three hours. The evaporators were working under normal conditions, mill working day shift only.

The data are as follows:

ENTRAINMENT FROM FOURTH CELL INDICATOR.

| Date | Time in hrs. | Net lbs. | Analyses | | | Vacuum | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1st Cell | 2nd Cell | 3rd Cell | 4th Cell | Cdnser |
| | | | Brix. | % Pol'n. | Purity | Vacuum | Vacuum | Vacuum | Vacuum | Vacuum |
| 9/18/22 | 12 | 211 | 10.09 | 8.36 | 82.85 | 1.70 | 7.08 | 13.75 | 24.3 | 26.42 |
| 9/19/22 | 12 | 220 | 11.15 | 9.25 | 82.96 | 1.70 | 7.50 | 14.33 | 25.5 | 27.00 |
| 9/20/22 | 12 | 208 | 11.00 | 9.21 | 83.73 | 1.00 | 6.84 | 13.83 | 25.6 | 27.00 |
| 9/21/22 | 12 | 199 | 12.39 | 10.38 | 83.78 | .67 | 7.67 | 14.42 | 25.8 | 27.00 |
| 9/22/22 | 12 | 205 | 16.33 | 13.75 | 84.20 | 1.67 | 8.33 | 14.30 | 26.0 | 27.10 |
| 9/23/22 | 8 | 131 | 13.50 | 11.12 | 82.37 | 0 | 5.50 | 12.90 | 25.8 | 26.90 |
| True Av. | 68 | 1174 | 12.31 | 10.27 | 83.43 | 1.16 | 7.15 | 13.92 | 25.50 | 26.90 |

Syrup brix and purity, 60.99 and 85.2 respectively, for the week ending September 23, 1922.

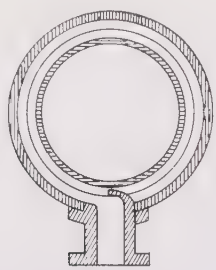
The fourth effect is a Catton Neill Evaporator, 7 feet in diameter containing 910 tubes, 1⅞ inches I. S. diameter by 54 inches long, giving 2010 square feet H. S. Height from top of tubes to center of vapor pipe, 9 feet 6 inches. The two vapor pipes to the central condenser are 24 inches diameter. Each vapor pipe is fitted with two screens, one 5x5 mesh, the other 3x3 mesh, to retard any particles of syrup going over. These screens are placed 5 feet apart, the smaller mesh, placed nearest the condenser.

Using the above figures, the calculated velocity of the vapor to the condenser is 112.06 feet per second.

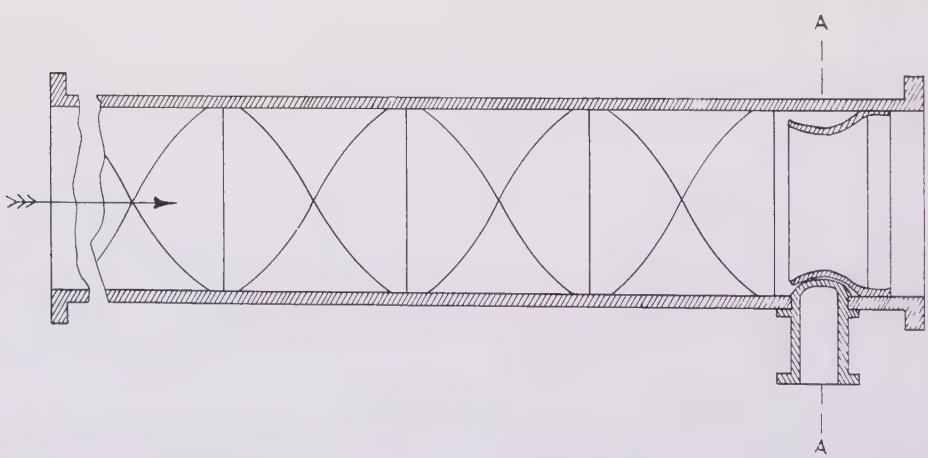
$$\frac{1174 \times .1027}{96.5} = 124.94$$ lbs. 96.50 deg. sugar that is returned to the fourth cell for week, or 1.84 pounds per hour.

A plan and description of the entrainment indicator is given on page 327 of the *Hawaiian Planters' Record*, December, 1921.

Mr. A. Barker, Engineer at Halawa Plantation, presents the following description of an entrainment catcher of his own design:



SECTION AT A.A.




During the latter part of this season, a new type of entrainment trap was fitted to the last effect at Halawa, with very noticeable effect and success. From the time we commenced grinding, it was evident, by mere observation of the waterlegs of the third effect and small pan, that heavy entrainment was taking place. I suggested putting in an entrainment catcher of my own design and it was agreed to try one. This was made at the plantation and fitted on May 24, 1922. It has been in operation ever since.

This entrainment catcher is fitted in the regular vapor pipe from the third effect and no new castings are required, in fact everything can, if required, be made at the mill. It consists of two principal parts, a true screw and a Venturi tube. Its action is based on the fact that the vapors passing to the condenser are travelling at a very high speed, in this case, for the season, it averages 14,414 feet per minute.

A true screw of 4 feet pitch was inserted for a length of 8 feet in the vapor pipe, giving a centrifugal force 4.8 times greater than a 30 inch machine at 1200 r. p. m. By this means, all liquids in suspension are thrown out to the walls of the pipe and no liquid or

particles of liquid can possibly reach the end of the screw without reaching the walls, and splashing on these walls is, of course, negligible.

Now, of course, by altering the pitch of the screw, the centrifugal force may be increased to any desired extent and consequently, for any known speed and diameter of pipe, the requisite pitch can be determined easily when the length of screw is known, as this affects the important factor, the time factor.

At the end of the screw is a Venturi tube. All the liquids on the walls of the pipe either return along the vapor pipe or are caught between the Venturi tube and the walls and returned by the pipe to the third effect.

In this case, with 16 inch pipe, the Venturi tube was restricted to 13.5 inches and yet no loss of vacuum was observable. Sugar bubbles were no longer seen at the foot of the water leg and alpha napthol always showed a negative test to the condenser water.

In August, Mr. McCleery visited the mill and sampled the water from the water leg and the flume, which water was being used as condenser water. His figures show that we were losing about 8 pounds of sugar per day. A series of tests were then made and the average of these was 17.44 pounds sugar lost per day or 1.608 tons for a season of 185 days, giving a saving of 128.442 tons pol. for season.

In designing a catcher of this type, the speed of the vapor is not only made use of but is increased if necessary to give the necessary centrifugal force that enables the particles of liquid to reach the walls of the pipe in the time allowed. This factor of time is the principal one to be considered, and, in conjunction with the rate of boiling, vacuum carried, length of pipe available and diameter of pipe, determines the pitch of screw and size of Venturi tube; and the fact that this catcher as fitted saved over 128 tons pol. during the season is an indication of what can be done with one of efficient design, though the labor employed in manufacture was of the regular unskilled mill type.

Mr. Charles P. Bento, Sugar Boiler of Wailuku Sugar Company, sent us a sketch with the following description:

In experimenting for the best way of working the baffle plates of save-all we have come to the conclusion that by putting three baffle plates in the front and two in the back with ¼ inch mesh screen in between it would work the best.

In testing the save-all we have two 3-inch pipes connected from save-all to two small tanks on the evaporator floor, one three-quarter inch pipe connected to a small surface condensor on the vapor pipe back of the save-all, leading down to a small tank on the evaporator floor, and from that surface condensor we would detect the entrainment going over. At the end of the season we noticed that the two inch tubes on the baffle plates were corroded with sugar and hard to clean.

The following letter was received from Mr. Searby, Assistant Manager of American Factors, Ltd., giving a tabulation of the various additions and improvements of the factories under its control:

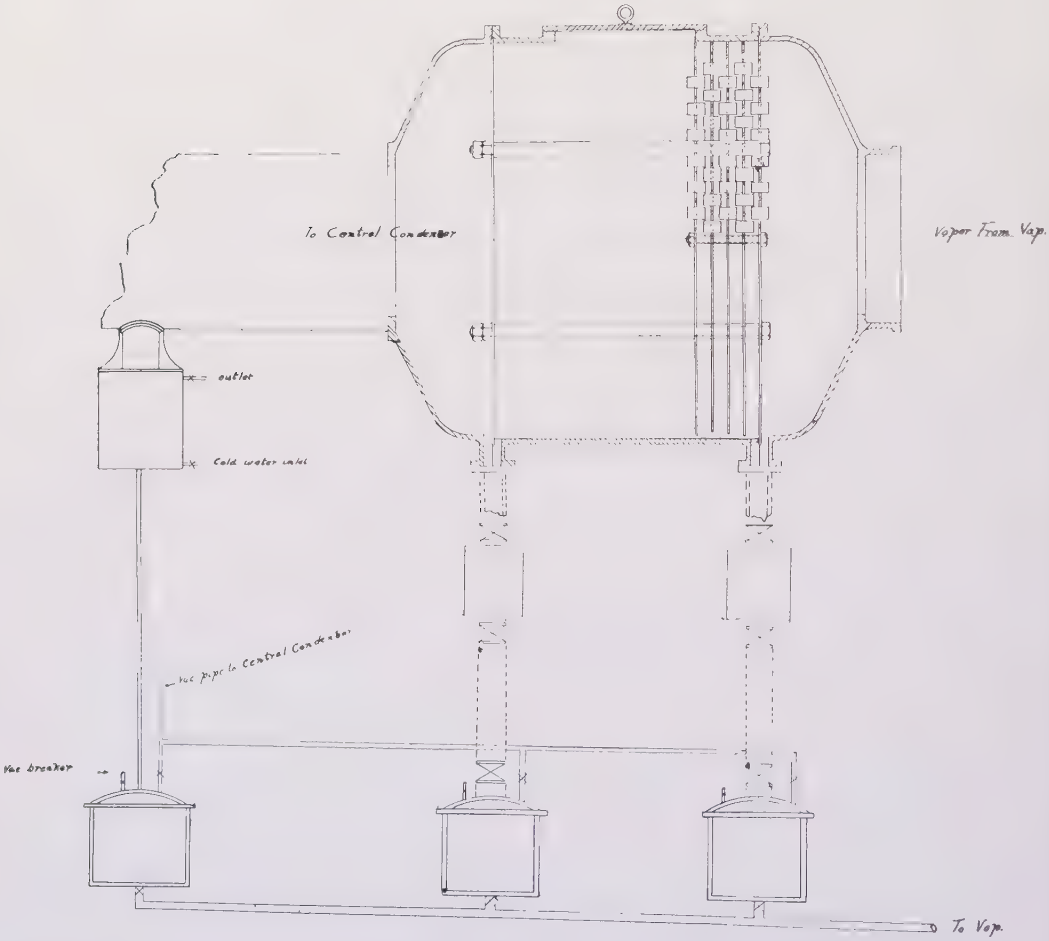
**Lihue:** The addition of two cells of 4000 square feet heating surface each to the existing quadruple effect of 8800 square feet, and the rearrangement of connections so that the old first and second cells and third and fourth cells act as first and second effects respectively of an enlarged quadruple effect, has practically doubled the evaporator capacity of this factory.

This has permitted an increase in the grinding rate of 9% and in the dilution of about 40% while at the evaporator the brix of the syrup has been increased from 56 to over 60.

The advantages of this being able to apply a dilution commensurate with milling equipment and tonnage ground, as well as to evaporate to a satisfactory density, need not be commented upon here. The advantages of an increased grinding rate have been recognized in the last two years particularly where the efficiency of the loaders has been

such that more cars have been needed to handle the same amount of cane and where there has been an actual shortage of cars.

Bringing of evaporators to the above standard has permitted cutting out two heaters which were previously necessary to bring clarified juices to the temperature of boiling in the first cell, this being necessary to enable the first cell, and consequently the entire set, to work at its maximum capacity. The direct result has been a reduction in cleaning expense.




The addition of eight 30 inch centrifugals and four crystallizers has brought the capacity at both of these stations to slightly above standard, and the molasses purity of 36.6 for the season has demonstrated the value of ample capacity for low grade work.

**Makee:** Among the improvements at this factory may be mentioned the installation of four 7'x20' H. R. T. boilers of 315 B. H. P. each to replace four 6' 6"x18" H. R. T. lap seam boilers of 171 B. H. P. each, two 900 square feet H. S. juice heaters, one 1800 cubic feet and 1800 square feet H. S. Calandria vacuum pan, and the installation of two motors, a 100 H. P. motor to drive 13-40" B. D. Centrifugals, and a 30 H. P. motor to drive the crystallizers and sugar handling equipment, to replace a 16"x36" Corliss Engine. The power to drive these motors is obtained from an hydro-electric plant above the Mimino Reservoir where an obsolete wheel having six runners each of a different diameter for maintaining different voltage or frequencies has been replaced by an up-to-date Pelton wheel with Woodward oil governor actuating a stream deflector.

**Olaa:** The new equipment installed at this factory consists of—

7 7'x20" H. R. T. Boilers.

1 1800 cu. ft. 1800 sq. ft. H. S. Calandria Vacuum Pan.

1 12"x27"x16" Ingersoll-Rand Dry Vacuum Pump.

1 10"x16"x10"x14" Air Compressor, and equipment for lifting a million gallon of water per day from two deep wells by means of air compression.

The first item of seven boilers all built in conformity with the A. S. M. E. Boiler Code, was to replace an equal number of the same size, but having lap riveted seams, and on which the working pressure had been reduced to such a point that their retention in service was inimical to fuel economy.

The 12"x27"x16" dry vacuum pump was installed to replace three water sealed, direct acting vacuum pumps on the pans and two smaller rotary vacuum pumps on the evaporators, one of the latter an Alberger, being retained to bring up the vacuum in the pans and evaporator before cutting in on the main pump.

The 1800 cubic feet Calandria Vacuum Pan is expected to assist in the steam balance at this factory, there being now four pans and opportunity to arrange working so there will be no extreme peaks in consumption. The substitution of copper for charcoal iron tubes in the three old pans is expected to improve the work in these pans by permitting faster boiling.

The air lift equipment has been installed to replace two deep well plunger pumps which have given continual trouble, due mainly to sand infiltration. The present wells and pumps having no movable parts are entirely free from this objection, and yield slightly over a million gallons of water per day against a head of 205' when supplied with 600 cubic feet of free air per minute. The advantage of having an auxiliary supply of fresh water for domestic use and condensing purposes when the natural run-off fails, needs no argument here.

**Kekaha:** During the present off-season this factory is installing 2 18-ton Calandria Vacuum Pans, each having a ratio of capacity to heating surface of one to one; sixteen 800 cubic feet crystallizers to replace an equal capacity in miscellaneous small tanks and coolers, 2 270 H. P. H. R. T. Boilers to replace two smaller size boilers which have been condemned, and four 40" American Tool and Machine Belt Driven Centrifugals. In addition a 700 square foot heater is being rearranged and fitted with baffles for a more efficient circulation of the steam and removal of incondensable gases.

Your committee wishes to thank those who have been kind enough to give their cooperation, and hope that these contributions may furnish material for a thorough discussion of the many unsolved problems we still have with us in the manufacture of sugar.

# The Influence of Fertilizers Upon the Productivity of the Soil.*

It was found, by growing barley under forcing-house conditions, on nine different types of soil consisting for the greater part of loams, the vegetative growth was influenced very little by the application of either litter or leaf-mould. During the first year's experiments, well-composted farm manure did not produce additional growth, although the results obtained with it the second year were satisfactory, but the plants to which commercial fertilizers were applied grew much more than those receiving stable manure, the quantities of nitrogen, phosphoric acid and potash being the same in the two cases. Slaked lime applied with farn manure had a very irregular effect according to the different types of soil; in short, nitrogen appeared to be the sole fertilizing substance having a marked influence upon barley.

To confirm these results, two soils were selected, one highly productive, and the other less fertile, and barley again planted. It was found that, under forcing-house conditions, the soils appeared to supply sufficient quantities of phosphorus and potassium for luxuriant vegetation.

The application to the soil of soluble compounds of nitrogen, phosphorus and potassium, materially increased the proportion of water solubles in the soil; these were used by the plants, and their amount was thus rapidly reduced before the barley had attained considerable growth. In the latter stages of its development, the quantity of the water-solubles remained constant and was much the same (with the exception of the phosphorus) as that present in the soil receiving no fertilizer.

To sum up; it would seem that from the practical standpoint, the above data show the importance of the solubility of the three essential ingredients of fertilizers, especially in the production of quickly-growing crops. Plants accumulate a large proportion of the required nitrogen and ash ingredients during the early stages of growth, for which reason, in the case of forcing-house culture, vegetable-gardening, and of such crops as cabbages, potatoes and wheat, an adequate supply of immediately available food appears to be indispensable in order to obtain good results.

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*From the International Review of the Science and Practice of Agriculture, Vol. XII, No. 10; abridged from Bulletin 473 of the N. Y. Agric. Exp. Sta., by W. H. Jordan.

# Some Notes On Rubber Estates of the Future.*

By Victor Ris.

## 1. The Influence of Selection of Planting Material on the Yield of Rubber Estates.

Until very recently, in fact, almost until the extensive opening up of rubber lands was discontinued in consequence of the rapidly decreasing price, all rubber estates in the East were planted up with more or less unselected seed. No selection on a clear scientific basis had been adopted anywhere, that is to say, nowhere to any appreciable extent.

The result of planting up such large areas with unselected material is now clearly to be seen everywhere and the following figures illustrate what may be considered to hold good for the majority of estates in the East when their full planted-up acreage is considered.

It may be said that 75% of the planted trees yield 40% of the crop and 25% of the planted trees yield the balance of 60%. These trees are hereafter referred to as Class A and Class B trees respectively.

Of the total number of planted trees on an estate 10% may be said to yield 25% of the crop whilst 1% of the total planted trees yield 5% of the crop. Such trees are hereafter referred to as Class C and Class D trees respectively.

Under "Class A" are included many trees which yield no latex or practically none. Under "Class D" are included trees whose records show they yield year after year between 55 and 60 pounds.

On the basis of these figures we can deduce that an average estate yielding at present 400 pounds per acre per annum could be expected to yield if planted:

| | | | | |
|---|---|---|---|---|
| With trees | described as | class "B" | 960 lbs. | per annum |
| do | do | class "C" | 1000 | do |
| do | do | class "D" | 2000 | do |

The figures further clearly prove what has been already stated above, *i. e.* that not only has unselected planting material been used for planting up estates, but that, taken on the average, poor planting material has been used and that it is most important that for future plantings the planting material should be most carefully selected on scientific lines. In the Dutch East Indies this urgent need has been recognized for a good many years and the highly trained staffs of botanists attached to the experimental stations, and I may here especially mention the Research Stations of the Avros, have been extensively engaged on work connected with the Hevea selection problem. The results of their research work so far obtained show:

(a) That the greatest success is attained in grafting or budding parts of selected high yielders on to the young root system of ordinary trees, thereby solving the problem of multiplication of high yielders in a short space of time.

* From the *Archief voor de Rubbercultuur*, Vol. VI, No. 6, 1922. Translated by the Agricultural Bulletin of the Federated Malay States.

The stems developed from such buddings show all the valuable characteristics of the mother tree. Structure of bark, number of latex carrying vessels, etc., in the offspring stem are equal to those in the mother tree. There is therefore every reason to believe that trees so grown will equal, or at any rate approximate, the yield of the mother trees.

In this connection it is interesting to note, as a further proof that the characteristics of the mother tree will be found in the tree grown from buddings, that the offsprings of yellow latex yielding mother trees yield also yellow latex whilst offsprings of white latex yielders yield white latex. As a matter of fact, one can go so far as to say that if an "eye" of a yellow latex yielder is grafted on to a white latex yielding stem, a tapping cut made at a later date across the grafting point yields in the upper part yellow latex and in the lower portion white latex. This is mentioned, of course, merely as a side light on the possibilities of grafting.

Grafting has passed out of the experimental stage and it can be adopted with the best results for any new rubber clearings. It is a fact that some hundred thousand graftings already have been carried out with complete success and grafting material from highly selected trees is beginning to form an "article of commerce." First class material now is being very eagerly sought for in many quarters. The Avros Research Station alone supplied to its members in 1921 about 6,000 meters of branch of selected trees. One meter carries about 10 sleeping eyes suitable for budding.

(b) The slower process of multiplication of high yielders, *i. e.* the process of generative selection, is also being very carefully gone into and satisfactory results have already been obtained.

After extensive and often pretty costly experiments it has been possible to obtain self pollination on some selected high yielders. In this way it becomes possible to arrive eventually at the isolation of biologically speaking "pure lines," the selection which is considered to be the ideal one. This selection naturally will take time before full results are obtained, because "pure lines" can be determined only as such after several generations have proved to show constant characteristics, *i. e.* proved that the characteristics are hereditary. Moreover even if full results are eventually obtained such "pure line" selection and production of "pure line" seed will very probably never yield sufficient seed for planting up large areas.

The limited number of high class pure line seeds will in all probability mostly be used for growing trees to be used for budding material. Budding as mentioned under (a) will therefore remain most probably the principal method of multiplication of high yielders in a short space of time.

## 2. The Influence of the Selection of Soil on the Yield of Rubber Estates.

Until quite recently, it was taken for granted in the rubber world that *Hevea Brasiliensis* would grow a paying crop almost anywhere in the tropics. That Hevea can grow anywhere, or at least keep alive anywhere, is proved to be about correct, but the idea that Hevea would yield a paying crop anywhere has

been proved to be a fatal mistake. Such mistakes have been made in every rubber planting country in the East; any soil from bare sand flats, peat land to abrupt and rocky hill sides, all classes of soil have been planted up.

The range available for comparison, so far as yield per planted acre goes, is therefore a very wide one and instances of the extent to which the quality of the soil influences the yield per acre are not far to find. They are at hand in every rubber producing country. I intend to deal hereafter especially with conditions prevailing in the East Coast of Sumatra, but all that is to be said can be taken as holding good, *mutatis mutandis,* in other eastern rubber producing countries.

The bulk of the estates are, as already stated, planted up with unselected seeds originating all from the same sources and the estates, therefore, from this point of view, can be taken as being built up on parallel lines. The seed factor can thus be eliminated when the yields of different soils are compared; so also can climatic conditions which are excellent from seacoast to the foot of the hills, from south to north.

But the yield per acre varies from 250 pounds per acre to 600 pounds per acre in specially good fields, although considerably higher figures are recorded. It is now, I think, quite clear that such variations, a full 140% in yield, form the strongest indication, in fact the clearest possible proof, that the quality of the soil is a prominent factor determining (all other conditions being equal) the yield of the rubber tree.

Eliminating about 80,000 acres planted on East Coast yielding under 300 pounds per acre, the balance can be taken as yielding an average 400 pounds per acre per year. Now keeping in view that there are large fields capable of yielding 600 pounds (and over) one is forced to conclude that proper selection of soil influences the yield by an increase of 50%. Taking extreme figures in this connection, 250 pounds and 600 pounds, the influence would be by 140%.

### 3. The Combined Influence of Seed Selection and Soil Selection on the Yield of Rubber Estates.

Under heading (1) I have said that:

| | | | |
|---|---|---|---|
| An acre planted with | class "B" trees | would yield | 960 lbs. |
| do | class "C" | do | 1000 lbs. |
| do | class "D" | do | 2000 lbs. |
| On average soil yielding from unselected seeds | | | 300 lbs. |

Under heading (2) I explained that by soil selection the yield can be improved by 50% as compared with the yield of existing average estates. Therefore:

| | | | | |
|---|---|---|---|---|
| One acre class "B" trees planted on selected land can be expected to yield | | | | 1440 lbs. |
| One acre class "C" | do | do | do | 1500 lbs. |
| One acre class "D" | do | do | do | 3000 lbs. |

In the light of yields as now obtained on average rubber estates these figures seem extraordinary, but in my opinion one must look at same as possible figures, certainly so, as far as the intrinsic yielding capacity of selected fields is con-

cerned. The first two mentioned should be obtainable under reasonably careful selection of both factors, seed and soil, whilst the third should be obtainable under exceptionally favorable circumstances and is therefore more of theoretical interest only. Still, personally, I should not venture to estimate for such yields in respect of any larger rubber areas to be opened up in future notwithstanding that I am fully convinced that rubber estates can be laid out and show an intrinsic yielding capacity as stated for class "B" and class "C" trees.

But intrinsic yielding capacity and actually obtainable yields are two different matters. A number of factors such as, for instance, the necessity to rest a number of trees from time to time, the influence of the tapping system and tapping force on the yield, are factors which in practice must tend to keep the actual yield well below the maximum the trees are theoretically able to give.

As regards "resting" nothing at this juncture can be said for certain, but from past experience one can deduce the trees benefit greatly by being rested from time to time for shorter or longer periods.

As regards "tapping system" the final word certainly has not yet been said, but in all probability any new system for extracting latex from the trees will always be a system by which not the last drop of latex will or can be extracted and by which the cambium will not be overirritated. Past experience with drastic systems, the cause of Brown Bast and all the misery connected with such, have served as a good lesson.

So far as the influence of the factor "tapping force" goes, every one knows that in the way the tapping force must be used at present, little chance is given the individual tree to yield its best. Improvements as compared with present day methods will certainly be effected in the future but the actual results obtained by any large force, even the best, will always remain below estimated possible results. No large force will ever consist of ideal tappers only; one will always have to be content with average skill.

How these factors, and perhaps many others, will affect the actual yield if such is compared with the intrinsic yielding capacity, is difficult to ascertain at this juncture. A number of those who apparently forget to take the adverse factors into their calculations estimate future yields to reach 1500, 2000 and more pounds per acre, and others who are more conversant with the practical daily working of estates, do not hesitate to estimate for at least 1200 pounds. In my opinion the latter will be nearer reality than the former.

For the purpose of the following calculation I take a yield of 1000 pounds per acre per annum and in doing so, I am sure I am on the safe side. (Selection influence the yield of sugar cane* and cinchona by almost tripling the output as compared with former unselected cultivations.)

### 4. Calculation of Cost per Pound of Rubber for Estates in Full Bearing of 2,000 Acres Yielding 2,000,000 Pounds per Annum.

It can now be safely stated that estates producing 400 pounds per acre under no restriction scheme can place their rubber on the London market at an "all in cost" of 40 cents or say 8d per pound. Of that sum 26 cents represents "Estates Cost" and 14 cents the cost from f.o.b. to "Sold London."

* This evidently refers to the selection of better seedling varieties and not to bud selection work.—*The Record.*

The "all in cost" per pound for producers of 1000 pounds per acre would fall to about 25 cents or approximately 5d. per pound "all in."

The annual net returns per acre from estates yielding 400 pounds and 1000 pounds respectively therefore compare as follows:

| Selling price per lb. | Net return per acre yielding 400 lbs. | | Net return per acre yielding 1,000 lbs. | |
|---|---|---|---|---|
| 5 d. | loss | £ 5.—.— | | £ —.—.— |
| 6 d. | do. | 3. 6. 8 | profit | 4. 3. 4 |
| 7 d. | do. | 1.13. 4 | do. | 8. 6. 8 |
| 8 d. | | —.—.— | do | 12.10. 0 |
| 9 d. | profit | 1.13. 4 | do. | 16.13. 4 |
| 10 d. | do. | 3. 6. 8 | do. | 20.16. 8 |
| 11 d. | do. | 5. 0. 0 | do. | 25.—.— |
| 12 d. | do. | 6.13. 4 | do. | 29. 3. 4 |

The uncertain factors of government income taxes are of course left out of account.

The actual capital cost per acre of the existing 400 pounds yielders can probably be taken as falling between £50 and £60, whilst the cost of the 1000 pounds yielders to be opened up in future may be taken as lying between £70 and £80.

Considering the possibilities and merits of stringent selection of planting material and soil to be planted up, one is perhaps doing well to bear in mind the excellent results obtained in the Dutch East Indies during the latter half of the last century in the cultivation of the sugar cane, cinchona and tobacco, and to remember that no other Eastern Tropical colonies can compete successfully with the Dutch East Indies on the world's market in these lines.

*Medan, January, 1922.*

# Studies in Indian Cane No. 4.*

(Concluded from last issue.)

By C. A. Barber.

## Literature Concerning the Effect of Spacing on Tillering and on Other Crop Characters.

The most obvious way of regulating the number of canes produced at harvest time is by varying the number of sets planted per acre. Spacing experiments have been conducted wherever the sugar cane has been cultivated, for the seed material, in many cases obtained by cutting up canes perfectly fitted for passing through the mill, costs a good deal and figures largely in the balance sheet. In

* From Memoirs of the Department of Agriculture in India, Botanical Series, Vol. X.

some countries only tops are planted, namely, the upper, immature parts of the plant where there is no sugar, and the canes harvested produce these in sufficient numbers to plant up the new fields; but, in other places, tops are not available, as they form a valuable cattle food, and in India, for instance, are often the perquisite of the men from whom the cattle are hired for crushing the canes. We have already referred to the curious fact that, even in India, there are varieties which cannot be successfully reproduced from the matured cane sets, but such exceptions are comparatively rare. When the Samalkota farm was started in the Godavari District, it was the local practice to plant 25,000 to 30,000 sets per acre, and the cultivators were quite content to put aside Rs. 30 to Rs. 40 for the purchase of seed per acre. A series of experiments was therefore initiated with the number of sets planted, varying from 4000 to 30,000 per acre. The number of canes produced at harvest were counted and the amount of *jaggery* produced was estimated. These figures are now unfortunately lost, but the general conclusion arrived at was that, with proper treatment, each piece of land would produce the same weight of canes within comparatively wide limits, but that, when thick canes were sown at the rate of 12,000 sets to the acre, the maximum yield might be counted on, and that closer planting merely led to unnecessary expense in the purchase of sets. A similar series of experiments was made with *Reora of Benares* in Partabgarh in North India,[1] varying numbers of sets being planted per acre and the resulting yield of *gur* compared. Here too, 12,000 sets per acre were found to produce the most satisfactory results, and the larger number of sets usually planted by the ryots did not give any increased yield. At first it strikes one as rather curious that thick and thin varieties, with their greatly differing tillering power, would require the same amount of space for their best development. But it must be remembered that the number of buds per sets was considerably greater in *Reora* because of its short-jointed character. The number of sets planted per acre on different farms in North India appears, however, to differ very considerably and it is not known whether these numbers are the result of series of spacing experiments, such as those made at Samalkota and Partabgarh, or are merely an adoption of the local ryots' practice until such experiments can be conducted.

Stubbs[2] quotes a certain Mr. Skeete, who speaks of sets planted six feet apart, with the result that often 50-100 canes were reaped from one hole. We have been unable to verify this reference or to discover what country is spoken of, but it appears to be not at all unlikely, for Prinsen Geerligs[3] states, of San Domingo in the West Indies, that the canes are occasionally planted nine feet apart each way, which would mean only 538 sets to the acre, and presumably the tillering in such cases would be great enough to make up the requisite number of canes at harvest time. It is the custom at the Cane-breeding Station to give the thick canes more room than the thin, in spite of their smaller tillering power, and this appears to be the general rule in India where these two types of canes are planted on the same farm. There is, however, a much more liberal application of manure in the former case, for the thin canes are found to be unable to

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1 Clarke, Annett and Hussain, etc. Experiments on the cultivation of sugar cane at the Partabgarh Experimental Station, 1910-11. *Bull. No. 27, Agr. Res. Inst., Pusa,* 1911.

2 *Ibid,* p. 95.

3 Geerligs, H. C. Prinsen. *The World's Cane Sugar Industry, Past and Present,* p. 193, 1912.

assimilate such heavy dressings and, at the same time, to mature properly at harvest time. The object aimed at in each case is to obtain a full stand, with as great a weight of canes as possible, without unnecessary expenditure in costly seed material. The development of the cane clump is influenced by warmth, moisture, soil, and no strict rule can be laid down as to the most suitable spacing, and hence the importance of the very numerous experiments which have been made.

Several workers have dealt fairly fully with the relation between spacing and the number of canes reaped, and it will be necessary to consider their papers somewhat in detail. As other matters besides the influence on tillering are also included in them, it will be convenient to treat these papers as a whole, and append a summary of conclusions at the end under the several headings.

Stubbs, in 1892-93, conducted experiments with the local Louisiana canes by planting the sets at distances of 6″, 12″ and 18″ in rows five feet apart. The plants were first reared in a nursery and, as each was planted in its plot, care was taken that it was the result of the growth of only one bud. His results are given in the following table:—

| Spacing | Number Planted in March | Shoots in June | Shoots in October (Harvest) | Average Weight of Each Cane | Tonnage |
|---|---|---|---|---|---|
| 6″ ........ | 17,600 | 72,325 | 39,050 | 2.17 lb. | 42.55 |
| 12″ ........ | 8,800 | 51,188 | 32,964 | 2.49 lb. | 41.60 |
| 18″ .... ... | 5,860 | 37,230 | 29,070 | 2.60 lb. | 37.24 |

These figures show a greater number of shoots arising in the more closely planted rows, but a gradual diminution of the differences in these numbers as growth proceeded. Inversely, there was an increasing weight of individual canes with greater spacing, but the tonnage was greater in the closely planted plots. Stubbs concluded that tillering depends on room available, and that there is practically no limit to it, provided the space given is sufficiently ample. In 1894-95 he carried out the same experiment with much greater care, studying each plant throughout its growth. Five plants of each of the two varieties, the *Striped* and the *Purple,* were used in each experiment, so that altogether there were thirty plants. A book was kept of births and death by the chemists in charge, who also labelled each shoot as it appeared. At harvest each clump was dug up and the labels examined, the parent stalks were marked and their relation to their branches; each cane was separately weighed and analyzed. It is impossible to conceive of a more strictly scientific method, and the results are well worth study, especially as the conclusions arrived at are at variance in some respects with those of others to be referred to below. More shoots started with the wider spacing, but the ultimate number at harvest was practically the same.

The next pieces of work on the effect of spacing on the number of canes produced are in 1910, when independent experiments were conducted by Kilian and Muller von Czernicki in Java. Kilian's experiments[4] were made with *J. 247*, a late but good tillering variety, on dry loam, "strugge"[5] loam and heavy black clay. It is unfortunate that the control plot of the latter was destroyed by fire; this class of soil, namely heavy clay, is apparently less suited to *J. 247*, and the results recorded of the single experiment show that some unmentioned factor has intervened. This plot we have accordingly left out in the discussion, and confined our attention to the four others, on loam of varying fertility. Kilian planted his sets in rows 3½′, 4′, and 5′ apart, and a summary of his results is given in the appended table, averaging the duplicate plots.

| SPACING OF ROWS | | No. of Canes Reaped per Bouw | Weight of Canes per Bouw in Pikuls | Weight of Sugar Obtained per Bouw in Pikuls | Sucrose per Cent in the Juice |
|---|---|---|---|---|---|
| Dry Loam .................. | 3½′ | 65,089 | 2,070 | 197 | 13.76 |
| | 4′ | 62,771 | 2,056 | 201 | 14.06 |
| | 5′ | 59,163 | 1,978 | 199 | 14.33 |
| "Strugge" loam............. | 3½′ | 55,135 | 2,092 | 210 | 14.40 |
| | 4′ | 54,175 | 2,023 | 206 | 14.58 |
| | 5′ | 50,388 | 1,946 | 201 | 14.81 |
| Heavy Black Clay .......... | 3½′ | 40,907 | 1,633 | 162 | 14.23 |
| | 4′ | 48,277 | 1,745 | 181 | 14.60 |
| (No Control) | 5′ | 40,038 | 1,536 | 158 | 14.75 |

From this table it is seen that the number of canes harvested decreases regularly with the increased width of the rows; the total weight of cane varies in the same sense within narrower limits, suggesting that, with wider spacing, the canes are on the average heavier. The quantity of sugar obtained varies irregularly, the advantage in one case being on the side of closer planting. The sucrose in the juice, however, is interesting, in that there is a uniform rise as the rows are wider apart, and in this respect the aberrant third experiment falls into line, suggesting again that the thicker canes have richer juice. No reference seems to be made by Kilian to this rise in sucrose with wider spacing, but it agrees with the generalization of Kobus and Van der Stok that, in the same plot, the thicker canes have richer juice.[6] Kilian is perfectly justified in drawing the conclusion that the results do not point to any advantage in altering the four-foot rows which appear to be most usual in Java.

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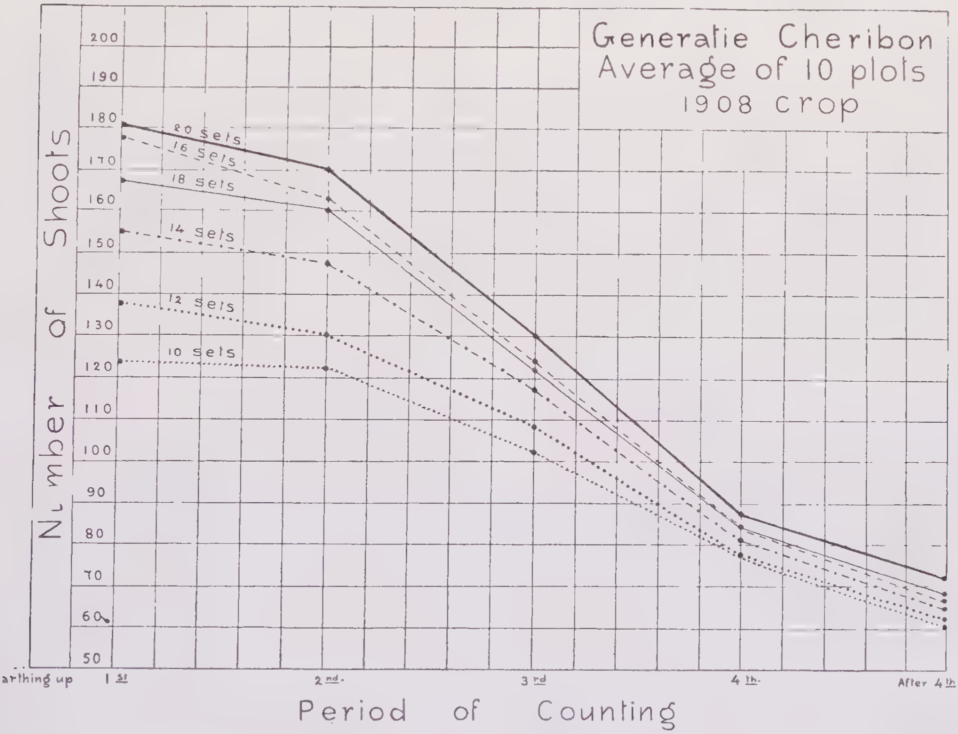
[4]Ibid.

[5]We have been unable to translate this word, but imagine that this loam is less fertile.

[6]J. E. Van der Stok, in Fruwirth's *Die Zuchtung der Landwirth-schaftlichen Kulturflanzen, Zuckerrohr.*

Muller von Czernicki's[7] experiments were on a much larger scale, and extended over several years. His work is the most important contribution which we have met with on the effect of spacing on tillering and the number of canes reaped, and deserves careful study. He had noted great variation in the spacing on different estates, without being able to find any reasoned justification for the local practices. For himself, on his Poerwodadi estates, it was a matter of considerable importance how many sets were used per acre, as much of the seed




Shoot-counting table, copied from Muller von Czernicki.

had to be imported and was expensive. He accordingly laid down a series of experiments to determine if equally good results could be obtained with a sparser sowing. He also wished to determine the relative tillering power of the different varieties and the time at which the maximum number of shoots was reached. At first he dealt with very large areas, planting them with rows 4 and 5 feet apart. There appeared to be no increase in the number of canes with the wider spacing, rather the reverse, and he decided to concentrate on varying the distance of the plants in the rows. But, in this case also, the results were inconclusive, and this he put down to the varying soil conditions and the impossibility of planting control plots in such large experiments. He therefore instituted a number of experiments on plots one-tenth of a bouw in area (practically 17 tenths of an

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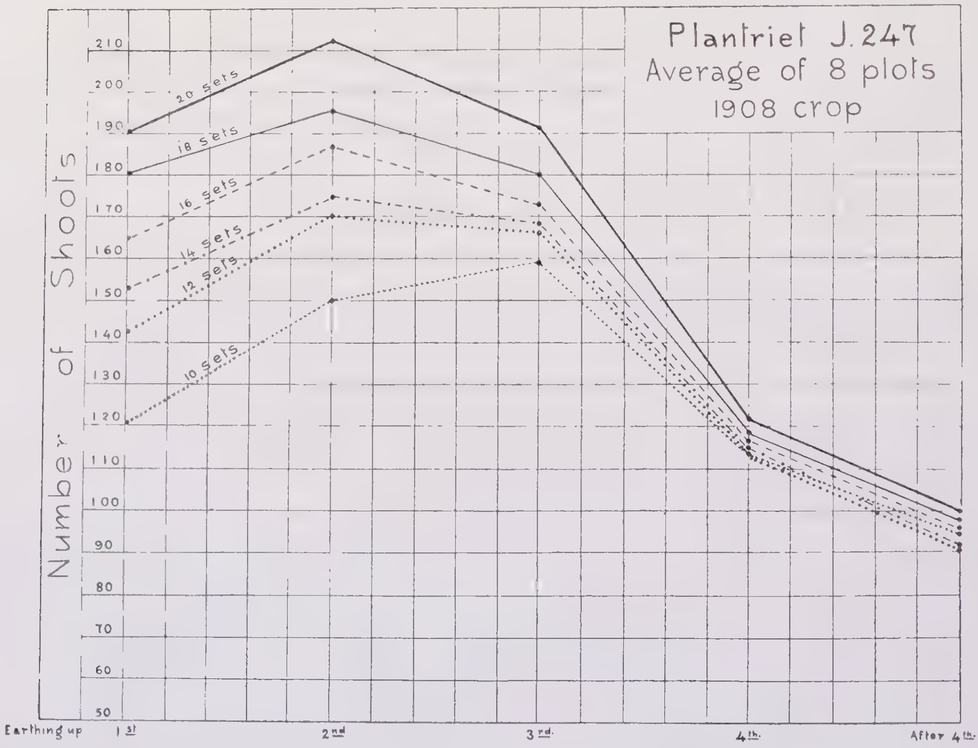
[7]Muller von Czernicki, C. F. Proefnemingen omtrent Plantwijdte. *Archief V. D. Suikerind. in Ned. Ind.*, Vol. XVIII, 1910, p. 314.

acre, or as it is termed in Madras, 17 cents). The rows were, as usual, 4 feet apart and about 30 feet long. In these he planted *Black Cheribon, J. 247*, and *J.* 100, varieties which were of importance in his area. The sets were planted 10, 12, 14, 16, 18 and 20 to the row. Countings were made of the shoots above ground at 60, 90, 120 and 150 days from sowing, which, presumably, roughly coincided with the different earthings up; and, 14 days after the last counting of shoots, he counted the canes formed, with a convention which seems to hold in Java of taking two or even three thin canes as the equivalent of one thick one. Muller von Czernicki complains repeatedly of the depredations of thieves and




Shoot-counting table, copied from Muller von Czernicki.

other injuries in his small plots; the presence of *sereh* is also commented on in the plots planted with locally raised seed, but these injuries are of less moment in the early countings, in which we are most interested here, than in the final crop. Numerous tables and graphs illustrate his paper and of these one table and two graphs are reproduced, as the paper is in Dutch and not easily available. In the table one notes with surprise the very early general development of branches from the sets, a steady decline usually following, after the first couple of months. Muller von Czernicki concludes as follows with regard to the three varieties tested:—

THE NUMBER OF SHOOTS COUNTED AT DIFFERENT PERIODS, WITH SETS PLANTED AT DIFFERENT DISTANCES APART—MULLER von CZERNICKI

1908 Crop.

| Number of Sets Planted per Row | Number of Plots Avergd | Number of Shoots Counted at: 1st Earthing Up | 2nd Earthing Up | 3rd Earthing Up | Last Earthing Up | After Last Earthing Up | Crop in Pikuls per Bouw (1¾ Acres) | Sucrose % in the Juice |
|---|---|---|---|---|---|---|---|---|
| **Generatie Cheribon.** | | | | | | | | |
| 10 | | 124 | 122 | 103 | 77 | 61 | 1,398 | 15.6 |
| 12 | | 138 | 131 | 108 | 77 | 62 | 1,416 | |
| 14 | 10 | 155 | 147 | 118 | 81 | 66 | 1,416 | |
| 16 | | 178 | 162 | 125 | 85 | 67 | 1,404 | |
| 18 | | 167 | 160 | 124 | 85 | 68 | 1,386 | |
| 20 | | 180 | 170 | 130 | 88 | 72 | 1,518 | 15.8 |
| **Plantriet No. 247.** | | | | | | | | |
| 10 | | 120 | 150 | 159 | 114 | 95 | 1,728 | 12.7 |
| 12 | | 143 | 170 | 166 | 114 | 92 | 1,554 | |
| 14 | 8 | 153 | 175 | 167 | 115 | 92 | 1,452 | |
| 16 | | 165 | 187 | 173 | 117 | 96 | 1,530 | |
| 18 | | 180 | 196 | 180 | 119 | 97 | 1,506 | |
| 20 | | 190 | 212 | 192 | 122 | 100 | 1,536 | 13.5 |
| **Generatie No. 247** | | | | | | | | |
| 10 | | 161 | 168 | 148 | 122 | 101 | 1,536 | 13.5 |
| 12 | | 191 | 178 | 155 | 122 | 98 | 1,422 | |
| 14 | 28 | 203 | 188 | 154 | 120 | 95 | 1,446 | |
| 16 | | 224 | 192 | 160 | 122 | 90 | 1,416 | |
| 18 | | 232 | 202 | 160 | 122 | 95 | 1,446 | |
| 20 | | 240 | 206 | 160 | 124 | 96 | 1,410 | 13.5 |
| **Generatie No. 100.** | | | | | | | | |
| 10 | | 98 | 128 | 124 | 100 | 82 | 1,140 | 16.7 |
| 12 | | 124 | 140 | 124 | 104 | 83 | 1,200 | |
| 14 | 3 | 127 | 148 | 123 | 104 | 83 | 1,220 | |
| 16 | | 142 | 150 | 128 | 104 | 83 | 1,220 | |
| 18 | | 157 | 146 | 126 | 106 | 86 | 1,320 | |
| 20 | | 168 | 156 | 124 | 106 | 86 | 1,320 | 15.6 |

*Cheribon* has the greatest number of shoots at 60 days, that is at the first counting; in the rows with ten sets the maximum is a little later, but at 150 days from sowing all the plots are approximately equal.

*J.* 247 tillers more slowly. When planted from sets, the maximum occurs at 90 days, and, in the 10 sets plot, at 120; when planted from tops, because presumably of the greater number of buds, the course of events is practically as in *Cheribon*.

*J.* 100 (of which only three plots were planted) reached its maximum number of shoots early, the plots with 18-20 sets at 60 days and the rest at 90 days, and after that period there was little difference in the plots.

An inspection of the table and graphs will convince the reader of the greater tillering of the widely spaced plants, where of course there were considerably fewer plants to the row, and the subsequent great mortality of shoots which soon reduced the numbers, till they were more or less uniform in all the rows—all the available light being used up.

The author draws the following conclusions regarding the possibility of reducing the number of sets planted per acre. This is of special importance with the costly imported material, and he points out that, with *Cheribon* and *J.* 100, it can be substantially diminished with safety. This also applied more or less to locally grown seed, but the danger of *sereh* is greater and the cost of the seed is much less, so that no change is suggested.

The experiments were repeated in 1909, with 8-20 sets per row, as it seemed to Muller von Czernicki that the lower limits of sowing had not been reached. The results confirmed those of the previous year. In *J.* 100, owing to a mistake, there was only one plot, but in the row with 8 sets a full stand was easily reached.

Muller von Czernicki makes certain observations as to the sucrose content of the mother cane and its branches. He states that some people seem to believe that the mother canes are richer than those developed later, but he cannot find any grounds for this belief. "After many years of observation," he has come to the conclusion that, provided that canes are ripe, there is little or no difference in this respect. He points out that the definition of mother shoots is a very loose one, and quotes Hovenkamp as saying that "mother canes need not be primary stems, but are the thicker and richer canes". We see elsewhere that the assumption is unwarranted, in that the canes of the third order of branching are almost always thicker than the mother canes. And we fail to see in what respect Muller von Czernicki's own deductions are more accurate, in that there are no references to stool dissections, and, without these, it is practically impossible to decide which the mother canes are. He, however, approaches the matter from another point of view. With closely planted sets, he argues, there will naturally be more mother canes than in the widely spaced rows, and this must make its influence felt, if there is richer juice in them, than in the branches; but he has not been able to detect any such difference. Muller von Czernicki's deduction would appear at first sight to be perfectly sound, but he does not go far enough.

Muller von Czernicki states that he has often noted the differences in thickness of canes sparsely and closely planted, especially in the 1909 experiments, and he decided to test this more carefully. He therefore measured 50 canes from

each plot in the following manner, making altogether 1,000 measurements. He used a pair of calipers which he moved round the stem until it encountered the greatest resistance, and took the measurements at about one metre from the ground at the middle of an internode. His results are given in a series of tables, in which the canes are arranged according to their thickness in each plot, with differences in millimetres. From these measurements in thickness he deduced the weight of the canes. By using a formula he calculated the difference in average weight of canes in the rows with 8 and 18 sets, the extremes of the series. This difference varied from 10.5 per cent. in imported *Cheribon* sets, to 17.6 per cent. in local *J. 247*. The average of these differences in the four kinds of seed used was 14 per cent., which means that 86 canes in the thinly sown rows would equal in weight 100 in the closer planted rows. In these deductions he assumes that the plants in the different rows were of equal height, but he himself observes that this was by no means the case; he therefore concludes that for accurate determinations of the weights of individual canes direct weighings will alone suffice.

Struben, in his paper on Tillering (1911), already mentioned, collates numerous countings of canes made by different workers, under the most varying conditions of climate, soil and treatment, and concludes that, within narrow limits, each variety shows the same cane-producing capacity, limits narrow enough not to be of appreciable influence from the crop point of view. He further gives the results of a series of experiments conducted by himself on the lines laid down by Muller von Czernicki. He experimented with *J. 247* and placed 6, 8, 10, 12, 14, 16 and 20 sets in separate rows of the same length, counting the canes at harvest in each case. The following table summarizes his results:—

CANES REAPED AT HARVEST

| Sets per Row | J. 100: Heavy Clay | | Cheribon: Fertile Land | | Cheribon: Infertile Land | |
|---|---|---|---|---|---|---|
| 6 | 74 | 85 | 63 | 68 | 65 | 70 |
| 8 | 76 | 89 | 69 | 70 | 75 | 80 |
| 10 | 82 | 89 | 70 | 72 | 82 | 84 |
| 12 | 85 | 92 | 69 | 76 | 85 | 86 |
| 14 | 91 | 86 | 72 | 76 | 86 | 85 |
| 16 | 95 | 86 | 71 | 76 | 86 | 84 |
| 20 | 94 | | 72 | 74 | | |

Looking at the figures as a whole, there is a general rise in the number of canes, at first rapid and then slow, as the number of sets per row increases; but this rise appears to receive a check when 12-14 sets per row are reached, and after this there is usually equality or even a slight decline. In only two cases of the six is there anything like a general rise throughout. But the counting of fully formed canes is not a true measure of tillering power, and Struben's figures do not help us in this respect to the same extent as do those of Muller von Czernicki.

The question of tillering power of the canes in the field, and the effect of this upon the harvest, is thus seen to be somewhat complicated. The number of canes

reaped at harvest is connected with the tillering power, but this connection is obscured by the great mortality of shoots during the growth of the plants and is therefore less close than might be expected. Similarly with the weight of canes at harvest, the weight of individual canes in the clump probably varies according to the date of appearance, and the average weight of canes varies with the closeness of planting and the corresponding number of total canes produced. The total yield of sugar depends upon the weight of the individual canes, their number and the richness of the juice. There is some evidence that the amount of sugar in the juice differs in branches of different orders. Spacing the planting material has its influence on all these factors, and it may be useful to summarize the views of the different writers already quoted, and to add such observations on the subject as have been accumulated from time to time at the Cane-breeding Station. The subject will be treated in the following order: The effect of spacing on the tillering power, as judged by the number of shoots produced per clump, and by the number of canes produced per clump at harvest; on the thickness and weight of the individual canes and the total weight of canes reaped; on the total yield of sugar in the crop. A note will then be added on the richness of the juice in branches of different orders in the clump.

*(a) Effect of spacing on tillering as judged by the number of shoots produced per clump.* Stubbs, in 1892-93, showed that, by planting the sets at 6″, 12″ and 18″ apart, the number of shoots produced differed a good deal. At three months after planting the 6″ plants had, on the average, 4.1 shoots each, those at 12″ had 5.8 shoots, while those at 18″ had 6.4 shoots per plant. Observations have not as yet been made on this point at the Cane-breeding Station. The following figures have been deduced from those published by Muller von Czernicki and referred to above. We have obtained them by dividing the maximum number of shoots in his countings by the number of sets in the row. The cases selected are the extremes and an intermediate one, namely, where sets were planted 10, 14 and 20 in the row. The following are the maximum numbers of shoots for these spacings: *Cheribon* (tops), 12.4, 11.1 and 9.0; *J.* 100 (tops), 12.5, 10.6, 8.4; *J.* 247 (tops), 16.8, 14.5 and 12.0; *J.* 247 (sets), 15.9, 12.5 and 10.6. The extreme differences in these spacings are roughly as 3 to 2 shoots per plant for the wider plantings.

*(b) Effect of spacing on the total number of canes per clump at harvest.* We are able to get more cases in which this has been observed, in that countings of canes at harvest appear to have been made regularly for many years in Java. Stubbs gives the figures for the canes at crop time (seven months from plantings), in Louisiana, and from these we find that the number of canes per clump at 6″ is 2.2, at 12″, 3.7 and at 18″, 4.9. Comparing these figures with those in section (*a*) we see that, although a number of shoots had died, the ultimate differences had increased.

Kilian gives the number of canes at harvest per bouw (1.75 acres) when the rows were 3½′, 4′ and 5′ apart, and we can obtain proportional figures for the number of canes per clump by multiplying these two sets of figures together. It is to be noted that the differences in spacing were not nearly so great as in Stubbs' experiments, but the results are still very definite. Taking the table given

on page 78, we get the proportional numbers as 4.6, 5.0 and 5.9 canes per clump in the richer land and 3.9, 4.3 and 5.0 in the poorer.

Muller von Czernicki does not give the numbers of canes at harvest, but counts them at 5-6 months, using the Java convention of taking two or three thin canes to one thick. Selecting the rows as before with 10, 14 and 20 sets, we get the following figures:—

*Cheribon* (tops), 6.1, 4.7 and 3.6; *J.* 100 (tops), 8.2, 5.9 and 4.3; *J.* 247 (tops), 10.1, 6.8 and 4.8; *J.* 247 (sets), 9.5, 6.6 and 5.0. Here again there is an increase in the differences in the numbers of shoots produced per plant as the period of harvest approaches, which is not to be wondered at, as the effect of the spacing should be cumulative throughout the growth of the plant.

The same author conducted spacing experiments on a very large scale, the plots extending over 100 bouws (175 acres) with sets planted roughly as 2 to 3 for the same space. This again is a smaller difference in space allowance than Stubbs', but the results are obvious enough. The numbers of canes per bouw are practically equal, showing that the effect of the spacing was that each clump, on the average, produced half as many canes again in the wider planting.

Wider spacing thus has a marked influence on the maximum number of shoots developed per plant; this effect is cumulative, during the period of growth, and is therefore intensified at the time of harvest.

(*c*) *Effect of spacing on the thickness or weight of the individual cane.* Stubbs gives the average weight of cane when the sets were planted 18″, 12″ and 6″ apart, in pounds as 2.60, 2.49 and 2.17. Kilian's results are less conclusive, but the distances apart in the 3½′, 4′ and 5′ rows were very much less. The relative weights in the two tables were as 3.2 to 3.3 to 3.35 and 3.8 to 3.75 to 3.85. There is thus practically no difference in the weights of the canes. Muller von Czernicki dealt rather carefully with the thickness of the cane, and he deduced the weights on the assumption that the canes were of equal heights (which he states from observation is not perfectly correct). He measured the canes at 5-6 months with calipers, in the rows with 8 and 18 sets in them. The result that he obtained from a large number of plots was that the canes in the 8 sets plots were 14 per cent. heavier than those of the 18 sets plots. Other observers, notably Kobus and Van der Stok, emphasize the fact that wider spacing increases the thickness of the individual canes, and it may be considered therefore as incontestable.

(*d*) *Effect of spacing on total weight of canes at harvest.* A wider spacing therefore produces more canes per plant, and these are thicker and heavier. But there are fewer of these plants to the acre. Stubbs gives figures for the total weight of canes reaped, with his spacing of 18″, 12″ and 6″ in the row, as 37.24, 41.6 and 42.55 tons per acre, a distinct though small advantage for the closer planting. Kilian's figures agree, taking the smaller differences into account in his spacing experiments. The total weights of canes in the 3½′, 4′ and 5′ rows were, in pikuls per bouw, 2070, 2056 and 1978 respectively. Muller von Czernicki in his larger plots of 3-5 acres obtained "no advantage in yield by planting widely (5′ instead of the usual 4′), rather the reverse," but the experiments he considered unsatisfactory because of variations in soil and the

impossibility of having any controls. In his carefully controlled smaller plots, again selecting the rows with 10, 14 and 20 sets in them, he gives the following weights of cane reaped in pikuls per bouw, *Cheribon* (tops), 1398, 1416, 1518; *J.* 100 (tops), 1140, 1220 and 1320; *J.* 247 (tops), 1536, 1446 and 1410; *J.* 247 (sets), 1728, 1452 and 1536, respectively. These figures are in favor of closer planting in the *Cheribon* and *J.* 100 plots but in the *J.* 247 they are inconclusive and in fact, have higher yields in both cases with the wider planting. (Has this anything to do with the known greater tillering power of this variety?)

On the whole, there seems to be a general concensus of opinion that wide planting reduces the yield in canes at harvest and the best distance apart will have to be decided for each variety, climate and soil as the result of experiments on the spot. With the generally higher yields of closer planting, it becomes a matter for the balance-sheet, especially where the sets are costly, for the price of the latter may then easily exceed the advantage gained by planting more sets to the acre, as was the case in the Samalkota tract referred to above.

(*c*) *The influence of spacing on total yield of sugar.* The factors of moment in the yield of sugar per acre are very numerous. The variety grown, the climate and soil, the character of cultivation, the efficiency of the manufacturing side, the number of canes per acre and their thickness, and the richness and quantity of juice, are all concerned. It is difficult to quote experiments where the effect of all these factors have been considered, but the various workers have given their opinions and these may be summarized, in that they are in general agreement. Within fairly wide limits, close planting appears to give a greater yield, but this is chiefly where the general level of cultivation is low. The local rate of planting is, in India, frequently excessive. This was clearly shown at Samalkota where the same yield in *jaggery* was uniformly obtained with thick canes by planting half the sets generally used. Similar results were obtained as to the maximum yield of *gur* in the experiments at Partabgarh, where, however, only one local cane was experimented with and that of course with a thin indigenous one. A somewhat similar result appears to have been obtained by Stubbs in Louisiana, for he recommends for the maximum crop the planting of the sets 6″ apart in 5′ to 6′ rows.

As to Java, Kobus lays it down as the result of his observations and experiments that even a difference of 10 per cent. in the number of canes per acre may very well go with the same yield of sugar. From this, we gather that the number of canes, which we have seen to be influenced by spacing, is not too closely connected with the yield of sugar, and therefore that the effect of spacing is of little import within moderate limits. This statement of Kobus is taken up by Struben, who argues in its favor and states that the Editor of the *Archief*, the principal organ of the Java industry, has long held the same view. Kilian's experiment of planting canes in rows, 3½′, 4′ and 5′ apart, gave results from which he gathers that, in *J.* 247, the current distance of 4′ cannot be altered with advantage. In the two controlled experiments on dry loam, the yields of sugar in pikuls per bouw for these spacings were respectively 197, 201, 199 and 210, 206 and 201; while another uncontrolled experiment on heavy black clay gave 162, 181, 158. Muller von Czernicki found, in crop experiments of 3 to 4 acres each over 175 acres, that a spacing varying as 2:3 made practically no differ-

ence as to yield of sugar. We may therefore conclude, that, with good cultivation, the yield of sugar, influenced as it is by so many factors, has no intimate relation to the spacing of the plants, and that this may accordingly vary within moderately wide limits without disadvantage. These limits have to be determined in each place with each variety separately.

### Note on the Relative Richness of the Juice in Branches of Different Orders

Kobus has made an oft-repeated generalization, after years of experiment, that, in a cane field, "thicker clumps have heavier canes and richer juice." Van der Stok also asserts that, in a general crop, the thick canes have more sugar in their juice.[8] Stubbs showed that, in the Louisiana crops, the mother canes had richer juice than the branches from it, but he failed to convince us that the earlier branches also had better juice than the later. In Java, writers generally take exception to this imputed superiority of the mother canes, and Muller von Czernicki asserts his conviction that, provided the crop ripens, as it generally does there, there is no difference in the juice of the different orders of branching. This rather discounts the Louisiana results, for a crop reaped at seven months from planting can hardly be considered by cane growers in the tropics as properly matured. But, on the other hand, we have failed to discover any indication that the true character of the branches has been determined in Java. After a good many dissections, we conclude that it would be a very difficult thing, without experience thus gained, to detect which are the mother canes of the crop. There seems, in general, to be a tendency to assume that these are thicker than the rest, but our results are exactly the opposite. We cannot, therefore, think that the opinions on this point either in Louisiana or in Java are altogether trustworthy.

A certain amount of work has been done at various times in the Laboratory of the Cane-breeding Station, on the richness of the juice in the different canes in the clump during growth and at crop time. In our study of early and late canes, we made use of the members of the Pansahi group, because, before we had made our dissections, it was easy to distinguish between the early and late canes. Some of the results of this study have been given in Memoir II, where it is shown that, in several varieties (*Maneria, Kahu, Yuba and Pansahi*), it was easy to separate the different classes of branches at crop time, and that, in their analysis, the earlier formed canes were invariably richer in their juice than the later. At the close of the 1917-18 crop, an attempt was made to divide the cut canes into classes, by observing the characters by which the branches of different orders could be separated, starting with thickness of cane and, where necessary, introducing length of basal part, average length of lower joints, curvature, etc. This separation was, as usual, found to be specially easy in the members of the Pansahi group. One hundred canes were thus dealt with in each of the varieties dissected and these were divided into their appropriate classes and separately analyzed. In *Maneria,* the percentage of sucrose in the different

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8J. E. Van der Stok, in Fruwirth's *Die Zuchtung der Landwirth-schaftlichen Kulturflanzen Zuckerrohr.*

classes from earliest to latest was 14.25, 13.74, 13.63, 13.57, 9.80, and in *Yuba* 15.17, 14.86, 13.14, 12.53 and 12.40.

It appears, from a great number of analyses which we have made at various times, that, while the plants are young, there is a great difference in the richness of the juice in the canes of different orders of branching, but that this difference gradually diminishes as the usual harvesting time approaches; and, when it has passed, that the juice of the earlier formed canes commences to deteriorate until it is distinctly poorer than that of later formed branches, which in their turn approach their optimum. This being the case, there will be a point of time in the life of each clump when the juice in the early and late canes tends to be of about the same richness, a period of equilibrium which may be regarded as the optimum of richness in the juice of the whole clump. It is probable that this point of time will vary in each clump of the same variety, even under the same conditions; it is likely that it will vary more in different varieties of the same group, and still more in the different groups. Besides this, the maximum richness of the juice in the clumps in any variety will naturally depend upon whether it is an early or late maturing kind.

# Boiler Heating Surface.*

Engineers have for many years past been in the habit of thinking of ten square feet of water-heating surface as a boiler horse-power, so called. Boilers were formerly not driven much beyond their normal rating and flue-gas temperatures around six hundred degrees Fahrenheit were regarded as consistent with good operation. Any heat-absorbing surface added to recover a portion of the heat lost in the flue gases was generally in the form of a cast-iron economizer and distinct from the boiler itself. Economizer surface is understood to consist of water-heating rather than steam-generating surface.

In recent years the steel-tube economizer has been introduced as well as the so-called integral economizer, which latter forms a portion of the circulating system of the boiler itself. It is generally not difficult in a boiler design embodying integral economizers to designate certain heating surfaces as economizer surfaces, for the arrangement of gas baffles, water circulation, etc., clearly indicate that such surface is essentially water-heating and not steam-generating surface.

Coincident with this development the builders of horizontal water-tube boilers brought out the so-called "high" boiler. Instead of the original nine by twelve tube high boiler, we now have available eighteen, twenty-one and even twenty-four tube high boilers. The high boiler with proper baffles will have lower flue-gas temperature than the old standard boiler with twelve tubes high and therefore, will operate at higher efficiency.

It has been stated that a portion of this added surface acts as a water-heating surface and is in a way equivalent to the surface of an integral economizer. This is not true in the case of practically all types of standard water-tube boilers with tubes inclined only slightly to the horizontal. The feed water in such boilers usually enters at the upper drum, where it comes in contact with the water which has risen from the tubes and which is in a state of ebullition, giving off steam. The feed is almost instantly heated to boiler temperature in the drum and passes down into the circulation system of the boiler along with the other boiler water. The tube surfaces receive only water at boiler temperature and, therefore, can never be considered as water-heating or economizer surface, but as true steam-generating surface.

The high boiler merely exposes additional heating surface to the furnace gases and by lowering the flue-gas temperature increases the boiler efficiency. High boilers cannot be forced to give the same average evaporation per square foot as the old standard boilers. These considerations emphasize still further the illogical definition of ten square feet of heating surface as a boiler horsepower. It seems apparent that engineers must revise their ideas of boiler ratings and consider boiler output, especially when they have the high boiler in mind.

[W. E. S.]

*From "Power," November 14, 1922.

# Annual Synopsis of Mill Data, 1922.

By W. R. McAllep.

All factories in the Association have furnished data for this Synopsis. All except eight of the forty-one had finished grinding on October 1, at which time it was necessary to have all schedules forwarded. The unharvested portion of the crop at these factories at the time data were forwarded, approximates 2.5% of the 1922 crop. The tabulated matter is presented in practically the same form as in the last few synopses. Analytical data and true average are in the first of the large tables, details of mill settings, etc., are in the second, and in the third details of surface and juice grooving now in use. Factories are listed in the order of the average size of the crop for the past five seasons.

## VARIETIES OF CANE

Varieties of cane ground to the extent of 1% or more of the total crop are tabulated in Table 1. This season the decrease in the tonnage of Lahaina has reduced this variety to fourth in importance, H 109 and D 1135 which were last season third and fourth now being second and third. The proportion of Yellow Caledonia is also diminishing. There is a marked biennial variation in the proportion of this variety and this is the principal factor influencing the comparatively large decrease shown this year. Figures for the last five years, however, indicate a gradual decrease. H 109 shows the largest increase. The proportion of D1135 has consistently increased from year to year. The Tip cane shows a fairly consistent increase.

Varieties included in the column "Other Varieties," that formed 1% or more of the crop at any one factory are:

| Variety | % of Total Crop |
|---|---|
| H 146 | 0.82 |
| Yellow Bamboo | 0.29 |
| H 20 | 0.17 |
| Badila | 0.15 |
| White Bamboo | 0.15 |
| H 291 | 0.03 |
| Total | 1.61 |

H 227 does not appear in the above tabulation, for though the tonnage was the same as that of H 291 it did not make up 1% of the crop at any one factory.

A comparison of Table 1 with the similar table in the Synopsis for 1914, the first year in which such data were compiled, shows the extent of the

## TABLE NO. 1.

### VARIETIES OF CANE.

| | Yellow Caledonia. | H 109. | D 1135. | Lahaina. | Striped Tip & Yellow Tip. | Striped Mexican. | Rose Bamboo | D 117. | Other Varieties. |
|---|---|---|---|---|---|---|---|---|---|
| H. C. & S. Co. | .. | 47 | 19 | 32 | .. | 2 | .. | .. | .. |
| Oahu | 5 | 31 | 16 | 39 | .. | .. | .. | .. | 9 |
| Ewa | 2 | 95 | .. | .. | .. | .. | .. | .. | 3 |
| Pioneer | .. | 32 | 2 | 21 | .. | 41 | .. | .. | 4 |
| Waialua | 11 | 17 | 25 | 17 | .. | .. | 1 | 3 | 26 |
| Maui Agr. | 4 | 40 | 11 | 23 | .. | 3 | 17 | .. | 2 |
| Haw. Sug. | 2 | 35 | 38 | 9 | .. | .. | .. | .. | 16 |
| Olaa | 90 | .. | 10 | .. | .. | .. | .. | .. | .. |
| Honolulu | 39 | 30 | 5 | 24 | .. | .. | .. | .. | 2 |
| Onomea | 70 | .. | 1 | .. | 29 | .. | .. | .. | .. |
| Hakalau | 91 | .. | .. | .. | 9 | .. | .. | .. | .. |
| Kekaha | 1 | 1 | 10 | 87 | .. | .. | .. | .. | 1 |
| McBryde | 33 | 44 | 23 | .. | .. | .. | .. | .. | .. |
| Hilo | 94 | .. | 5 | .. | .. | .. | .. | .. | 1 |
| Lihue | 92 | 5 | 2 | .. | .. | .. | .. | .. | 1 |
| Haw. Agr. | 51 | .. | 20 | .. | .. | .. | 3 | .. | 26* |
| Wailuku | 3 | 42 | 3 | 12 | .. | 31 | .. | .. | 9 |
| Makee | 97 | 3 | .. | .. | .. | .. | .. | .. | .. |
| Honokaa | 24 | 5 | 70 | .. | .. | .. | .. | .. | 1 |
| Laupahoehoe | 51 | .. | 8 | .. | 35 | .. | .. | 6 | .. |
| Pepeekeo | 97 | .. | .. | .. | 3 | .. | .. | .. | .. |
| Waiakea | 100 | .. | .. | .. | .. | .. | .. | .. | .. |
| Kahuku | 74 | 14 | 3 | 9 | .. | .. | .. | .. | .. |
| Koloa | 95 | 1 | 4 | .. | .. | .. | .. | .. | .. |
| Hamakua | 33 | 1 | 27 | .. | 8 | .. | .. | 31 | .. |
| Honomu | 98 | .. | .. | .. | .. | .. | .. | 1 | 1 |
| Paauhau | 58 | .. | 34 | .. | 5 | .. | .. | .. | 3 |
| Hawi | 23 | 32 | 18 | .. | 27 | .. | .. | .. | .. |
| Hutchinson | 41 | .. | 1 | .. | 1 | .. | 57 | .. | .. |
| Waianae | 1 | 82 | .. | 14 | .. | .. | .. | .. | 3 |
| Kaiwiki | 49 | .. | 10 | .. | 25 | .. | .. | 15 | 1 |
| Kilauea | 97 | .. | .. | .. | .. | .. | .. | .. | 3 |
| Kohala | 22 | .. | 23 | .. | 38 | .. | .. | .. | 17 |
| Kaeleku | 100 | .. | .. | .. | .. | .. | .. | .. | .. |
| Waimanalo | 96 | 2 | .. | .. | .. | .. | .. | .. | 2 |
| Niulii | 80 | .. | 11 | .. | 9 | .. | .. | .. | .. |
| Halawa | 50 | .. | 10 | .. | 40 | .. | .. | .. | .. |
| Waimea | 1 | 20 | 3 | 75 | .. | .. | .. | .. | 1 |
| Olowalu | .. | 47 | .. | 35 | .. | 18 | .. | .. | .. |
| Union Mill | 24 | 3 | 6 | .. | 66 | .. | .. | 1 | .. |
| Kipahulu | 100 | .. | .. | .. | .. | .. | .. | .. | .. |
| True Average 1922 | 40.3 | 21.1 | 12.2 | 12.0 | 4.3 | 2.8 | 1.6 | 1.2 | 4.5 |
| " " 1921 | 45.1 | 15.0 | 11.0 | 17.4 | 3.0 | 3.0 | 1.0 | 1.1 | 3.4 |
| " " 1920 | 42.7 | 9.1 | 10.0 | 26.7 | 3.5 | 2.5 | 0.8 | 1.0 | 3.7 |
| " " 1919 | 46.4 | 6.8 | 7.2 | 29.1 | 2.9 | 1.8 | 2.1 | 1.1 | 2.6 |
| " " 1918 | 42.9 | 4.0 | 7.5 | 37.9 | 2.0 | 0.6 | 1.1 | 0.8 | 3.2 |

*White and Yellow Bamboo 12%.

tendency to extend the minor varieties over considerable areas. In that year no single minor variety was ground to the extent of 1% or more of the crop, at more than 15% of the factories. The total tonnage, with the exception of a comparatively small proportion, was made up of Yellow Caledonia and Lahaina. This season D 1135, the third most important variety, is reported from 70%, while the fourth and fifth varieties, Lahaina and the Tip canes, are each reported from a third of the factories.

## QUALITY OF CANE

The quality of the cane has been poorer than in any previous year, not excepting the low point reached in 1918. The difference between 1921 and 1922, however, is not very great, amounting to slightly over .03 in quality ratio. Juices have been higher in purity than last year, but lower than in any other season. The fiber has been higher than in any previous year.

Table 2 is the composition of the cane by Islands. On Kauai only was the quality better than during the preceding season. On Oahu the quality was practically the same. On Hawaii it was somewhat poorer than last year, but slightly better than in 1918. On Maui it was considerably poorer than in any previous season.

## MILLING

The factories are arranged in the order of the size of their milling loss in Table 3. Two factories, Hakalau and Onomea, have bettered the record for milling loss of 1.16 made by Onomea last year. Three factories report milling losses under 1.5 against 5 last year, while 16 report under 3.0 against 21 last year. None of the factories this year secured 99 extraction. Five report better than 98 extraction against nine last year. Marked improvement is reported from the five factories at the bottom of the list. Two factories only report milling losses higher than 5.5 against four last year.

Olowalu, Pioneer, Paauhau, Waialua, and Kaeleku have materially improved their relative standing in the tabulation though only the first two report better work. Ewa, Maui Agricultural Company, Honokaa, and Waianae are materially lower in their relative standing.

This is the first time since 1911 that the milling work has failed to show an improvement over that of the preceding season. The average milling loss compared with last year has increased from 2.64 to 3.02 and the extraction has dropped from 97.43 to 96.98. Figures for milling loss, extraction ratio, and extraction indicate that the quality of the work has been of about the same order as in 1917.

The averages have been considerably affected by lower extractions obtained at three of the larger mills. At one of these the extraction was low because a half of the milling equipment only was available while a considerable portion of the crop was ground. At another on account of operating at higher capacity the cane was ground in two 12-roller tandems while last season one 15-roller tandem was used. Lower extraction at these two, to-

TABLE NO. 2.

COMPOSITION OF CANE BY ISLANDS.

| | Hawaii | Maui | Oahu | Kauai | Whole Group |
|---|---|---|---|---|---|
| 1913 | | | | | |
| Polarization ............. | 13.22 | 15.56 | 14.21 | 13.70 | 14.05 |
| Percent Fiber ........... | 13.74 | 11.73 | 12.75 | 12.50 | 12.85 |
| Purity 1st Mill Juice .... | 88.47 | 91.11 | 88.20 | 88.12 | 89.02 |
| 1914 | | | | | |
| Polarization ............. | 12.75 | 15.16 | 14.23 | 13.62 | 13.78 |
| Percent Fiber ........... | 13.62 | 11.59 | 12.44 | 12.75 | 12.74 |
| Purity 1st Mill Juice .... | 88.22 | 91.02 | 88.11 | 87.51 | 88.71 |
| 1915 | | | | | |
| Polarization ............. | 12.61 | 15.23 | 14.29 | 14.09 | 13.77 |
| Percent Fiber ........... | 13.00 | 11.44 | 12.77 | 12.46 | 12.51 |
| Purity 1st Mill Juice .... | 87.86 | 90.48 | 87.27 | 86.99 | 88.24 |
| 1916 | | | | | |
| Polarization ............. | 12.54 | 14.62 | 13.74 | 13.26 | 13.45 |
| Percent Fiber ........... | 13.22 | 12.22 | 12.51 | 12.86 | 12.74 |
| Purity 1st Mill Juice .... | 87.56 | 89.41 | 87.15 | 86.26 | 87.70 |
| 1917 | | | | | |
| Polarization ............. | 13.31 | 15.43 | 13.55 | 13.13 | 13.76 |
| Percent Fiber ........... | 13.23 | 11.67 | 12.25 | 12.89 | 12.62 |
| Purity 1st Mill Juice .... | 88.11 | 90.69 | 86.86 | 86.70 | 88.02 |
| 1918 | | | | | |
| Polarization ............. | 11.88 | 14.25 | 13.50 | 12.54 | 12.97 |
| Percent Fiber ........... | 13.35 | 11.53 | 12.23 | 12.84 | 12.50 |
| Purity 1st Mill Juice .... | 87.27 | 88.62 | 86.93 | 85.88 | 87.18 |
| 1919 | | | | | |
| Polarization ............. | 12.74 | 15.12 | 14.24 | 13.52 | 13.74 |
| Percent Fiber ........... | 13.07 | 11.74 | 12.14 | 12.61 | 12.49 |
| Purity 1st Mill Juice .... | 87.54 | 88.81 | 87.00 | 85.82 | 87.34 |
| 1920 | | | | | |
| Polarization ............. | 12.86 | 15.29 | 13.75 | 13.07 | 13.64 |
| Percent Fiber ........... | 13.36 | 11.39 | 12.65 | 12.72 | 12.64 |
| Purity 1st Mill Juice .... | 87.87 | 88.94 | 85.40 | 86.52 | 87.24 |
| 1921 | | | | | |
| Polarization ............. | 12.25 | 14.67 | 13.72 | 12.67 | 13.12 |
| Percent Fiber ........... | 13.28 | 11.82 | 12.40 | 13.28 | 12.80 |
| Purity 1st Mill Juice .... | 87.18 | 87.37 | 85.46 | 84.07 | 86.22 |
| 1922 | | | | | |
| Polarization ............. | 12.07 | 13.95 | 13.61 | 13.03 | 12.97 |
| Percent Fiber ........... | 13.16 | 12.38 | 12.88 | 13.22 | 12.95 |
| Purity 1st Mill Juice .... | 87.17 | 87.88 | 86.18 | 85.80 | 86.84 |

gether with poorer results secured at a third large factory reduce the average to the extent of almost 0.3, or some 60% of the whole decrease. While the decrease in the quality of the milling work has been rather general, 66% of the factories reporting higher milling losses, 62% higher extraction ratios and 72% lower extraction, the averages would have been depressed to a considerably smaller extent had it not been for the lower results secured at these three of the larger factories.

The average moisture in the bagasse has increased from 41.20 to 41.51%. The tendency has not been general, the factories reporting higher and lower bagasse moistures being almost evenly divided.

The pressures carried on the mills are not materially different from those reported a year ago. A half of the factories report the same pressure as before. Nine factories report heavier pressures, while eleven report lighter. Three or four of the latter report moderately large decreases. Taken as a whole the figures indicate a slight tendency toward lighter pressures.

The maceration has been reduced from 39.30 to 34.75, 64% of the factories reporting a decrease in the amount used. While higher moisture in the bagasse tends to indicate some decrease in the efficiency of the mills considered as machines for extracting juice by pressure, it is probable that the comparatively large reduction in maceration is a much greater factor in the poorer results secured.

Conditions during the past year have rendered it particularly desirable to curtail all avoidable expense, and the change in the quality of the milling work is, no doubt, largely a reflection of efforts in this direction. As the reduction in hydraulic pressure has not been general, and in only a few cases has it been enough to be of any consequence, presumably the saving in wear and tear on equipment has been small. The reduction in maceration, however, has been accompanied by a reduction in the amount of extra fuel burned, and in this direction savings in expenditures have been made. Such savings, however, have only been possible at factories where it has been the practice to burn extra fuel. It is significant that the four factories at the head of Table 3 have reported the use of no fuel other than bagasse and molasses either this or last year, and that three of these report improvements in milling. Considering the fiber content of the cane as a measure of the fuel available these factories are not particularly favored, for but one reports a fiber content higher than the average. The results secured at Pioneer are also significant. At this factory the fiber is considerably below the average and formerly extra fuel in considerable amounts was burned. The capacity of the boiling house has been increased and while making the change the evaporating and boiling equipment has been brought to an economical capacity. This together with changes in the boilers and the present method of operation has permitted an improvement in the milling work not only without the use of extra fuel, but with a credit to the mill for power supplied to outside points equivalent to 12% of the total amount of bagasse. It should be noted that in making new installations the extra cost of equipment of sufficient capacity to do the work economically over that of barely sufficient capacity to perform the work is usually but a moderate proportion of the total cost. Theoretically the

## TABLE NO. 3.—MILLING RESULTS.

Showing the Rank of the Factories on the Basis of Milling Loss.

| Factory | Milling Loss | Extraction Ratio | Extraction | Equipment |
|---|---|---|---|---|
| 1. Hakalau ....... | 1.10 | 0.09 | 98.84 | 2RC54,12RM9-60,3-66 |
| 2. Onomea ........ | 1.15 | 0.09 | 98.79 | 2RC60,S54,12RM66 |
| 3. Hilo .......... | 1.29 | 0.11 | 98.48 | K,2RC60,12RM66 |
| 4. Pepeekeo ....... | 1.88 | 0.16 | 98.00 | 2RC54,9RM60 |
| 5. H. C. & S. Co. .. | 2.14 | 0.14 | 98.19 | K(4),2RC78(2),S72(2),12RM78(2) |
| 6. Paauhau ....... | 2.34 | 0.20 | 97.30 | 2RC60,12RM66 |
| 7. Makee ......... | 2.43 | 0.21 | 97.06 | K,2RC72,S72.9RM72 |
| 8. Wailuku ....... | 2.45 | 0.19 | 97.69 | K,2RC72,12RM78 |
| 9. Koloa .......... | 2.54 | 0.21 | 97.09 | K,2RC60,12RM66 |
| 10. Lihue ......... | 2.55 | 0.21 | 97.20 | K,2RC78,S72,12RM78 |
| 11. Pioneer ........ | 2.58 | 0.18 | 97.79 | K,2RC72,S72,15RM72 |
| 12. Haw. Sug. ..... | 2.62 | 0.17 | 97.82 | K.2RC72,S72,12RM78 |
| 13. Haw. Agr. ..... | 2.62 | 0.22 | 97.06 | 3RC60,12RM66 |
| 14. Honomu ........ | 2.66 | 0.22 | 97.34 | 2RC60,9RM60 |
| 15. Olowalu ........ | 2.70 | 0.20 | 97.53 | K,3RC48,9RM48 |
| 16. Kilauea ........ | 2.73 | 0.25 | 96.71 | K,S,3RC60,9RM60 |
| 17. Waimea ........ | 3.04 | 0.22 | 97.45 | 2RC48,12RM42 |
| 18. Laupahaehoe ... | 3.22 | 0.26 | 96.66 | K,2RC60,9RM60 |
| 19. Waialua ....... | 3.32 | 0.24 | 96.97 | K(2),2RC78,12RM78 |
| 20. Honokaa ....... | 3.33 | 0.29 | 96.27 | K(2),2RC66,12RM66 |
| 21. McBryde ....... | 3.38 | 0.25 | 96.43 | 2RC72,S72,9RM84 |
| 22. Olaa .......... | 3.38 | 0.28 | 96.26 | K,S72,12RM78 |
| 23. Maui Agr. ..... | 3.45 | 0.25 | 96.99 | K(2),3RC66,18RM66 |
| 24. Hawi .......... | 3.52 | 0.26 | 96.79 | K(3).3RC48,12RM3-48,9-54,2RC54, 12RM54 |
| 25. Hutchinson ..... | 3.75 | 0.33 | 95.72 | 2RC60,9RM60 |
| 26. Oahu .......... | 3.76 | 0.26 | 96.73 | K(2),2RC78(2),S72,12RM78(2) |
| 27. Kahuku ........ | 3.77 | 0.32 | 94.95 | 3RC60,S54,9RM72 |
| 28. Kaeleku ....... | 3.77 | 0.34 | 95.06 | K(2),2RC54,9RM60 |
| 29. Kekaha ........ | 3.80 | 0.28 | 96.59 | 2RC54,9RM60 |
| 30. Ewa .......... | 3.95 | 0.30 | 96.19 | K(2),2RC78,18RM78 |
| 31. Waianae ....... | 3.96 | 0.29 | 96.07 | K(2),12RM60 |
| 32. Honolulu ....... | 4.00 | 0.29 | 96.51 | K(2).S54,2RC78,9RM78 |
| 33. Kohala ......... | 4.09 | 0.32 | 95.72 | K(2).3RC60.9RM60 |
| 34. Kaiwiki ........ | 4.14 | 0.33 | 95.34 | K.2RC60.9RM60 |
| 35. Waiakea ....... | 4.49 | 0.36 | 95.18 | K,S42,2RC60,9RM60 |
| 36. Hamakua ...... | 4.54 | 0.35 | 95.15 | K 2RC60,12RM60 |
| 37. Union Mill ..... | 5.14 | 0.42 | 93.84 | K.9RM60 |
| 38. Halawa ........ | 5.41 | 0.48 | 93.48 | K.2RC60,6RM50 |
| 39. Niulii .......... | 7.93 | 0.65 | 91.40 | K,9RM54 |
| 40. Kipahulu ....... | 8.16 | 0.69 | 90.35 | K.5RM3-42,2-54 |

bagasse, particularly when supplemented with molasses, should furnish sufficient fuel to maintain a high quality of work and the above indicates that with equipment suitable for the conditions at the factory in question and with proper operation, this is also the case in practice.

In the greater number of Hawaiian factories additions have been made to the equipment from time to time. In some cases the changes have conformed to well considered plans, taking into consideration the conditions under which the factory must operate, while in others the results of the changes are installations decidedly faulty from the standpoint of fuel economy. Providing a factory has been supplied with enough cane to operate at a reasonable capacity, whether or not a high quality of milling work has been substantially maintained under conditions involving the reduction of expenses to a minimum, is within certain limits a test of how closely the equipment conforms to sound engineering and thermodynamic considerations, and also as to whether or not previous high extractions have been secured by economical methods. Instances have come to the writer's attention where comparatively minor changes would permit an improvement in the work, or perhaps more accurately stated, with such minor changes a greater amount of useful work could be obtained from a given amount of fuel. At some factories, however, fundamental faults in design, render changes that would put them on a satisfactory basis from the standpoint of fuel economy, a much more extensive undertaking.

Had the quality of the milling work been the same as that of the previous year the average extraction would have been 97.40. The yield has been decreased by the amount of commercial sugar corresponding to the difference between 96.98 extraction and this figure. While the investigation of the yield of sugar from the last extracted juices has not been completed we have more definite information than was previously available on this subject. The experiments on last mill juice now completed and under way strongly indicate that these last extracted juices are at least as valuable for manufacturing purposes as would be inferred from their analyses. This indication has been confirmed in factory practice at Ewa during the past season. Comparison of the periods of low and high extraction, when a part only and the whole of the milling machinery was in use, indicates that the expected recovery due to the higher extraction in the latter period was fully realized. The writer considers 2000 tons of commercial sugar a conservative estimate of the reduction in the total 1922 output due to the lower extraction compared with that of the previous season. Balancing the value of this sugar against the saving in expenses that have resulted in lowering the extraction, would give valuable information.

Attention was called in the Synopsis for last year to the fact that the efficiency of the maceration is low. If this question receives the same study that has been given to other features of the milling work this efficiency will, no doubt, be greatly improved. We have here a most promising field for an improvement in the economy with which a high quality of milling work can be obtained.

As would be expected, with lower extraction the difference in purity between the first and last mill juices has been reduced from 20.33 last year to 17.71 this season. The difference between first mill and mixed juice purity has also been reduced from 3.45 to 3.11. While lower extraction has doubtless influenced the latter difference, detailed examination of the figures fails to indicate that it has been a major factor in bringing about the change. Twenty-seven factories report lower extraction than last year, thirteen of these report smaller differences in purity while fourteen report larger differences than last year; twelve factories report increased extraction and of these six report smaller and six larger differences.

The average differences in the years for which figures are available are tabulated below together with extraction and maceration data:

Difference in Purity between First Mill and Mixed Juices:

| Year. | Ext. | Maceration. | Purity Difference. |
|---|---|---|---|
| 1914 | 95.46 | 33.64 | 3.01 |
| 1915 | 96.30 | 35.04 | 3.49 |
| 1916 | 96.87 | 39.85 | 3.11 |
| 1917 | 97.05 | 39.39 | 3.14 |
| 1918 | 97.21 | 38.99 | 3.19 |
| 1919 | 97.30 | 40.80 | 3.05 |
| 1920 | 97.45 | 39.95 | 3.37 |
| 1921 | 97.43 | 39.30 | 3.45 |
| 1922 | 96.98 | 34.75 | 3.11 |

Changes in the differences tabulated above do not follow very closely changes either in extraction or in the amount of maceration. In 1915, a year in which the extraction was comparatively low the difference is abnormally large. There is an increase in 1920 accompanying a comparatively small increase in extraction and somewhat reduced amount of maceration. The difference in purity becomes still greater in 1921 with practically the same extraction as during the previous year and a further reduction in maceration. In other years the difference has fluctuated within comparatively narrow limits, and the 1922 figure is almost identical with the average of the years other than 1915, 1920 and 1921. These data strongly indicate that in actual practice, other factors have probably affected the difference between the first mill and mixed juice purities more than changes in extraction or in the amount of maceration. The care taken to keep the mills clean and the amount of field trash accompanying the cane are probably among the more important of these factors.

## GRAVITY SOLIDS AND SUCROSE BALANCES

These data appear in Table 4. As in previous years when suspended solids in mixed juice has not been reported, it has been estimated as 0.25%.

TABLE NO. 4.

GRAVITY SOLIDS AND SUCROSE BALANCES.

| Factory | Gravity Solids per 100 Gravity Solids in Mixed Juice | | | | Sucrose per 100 Sucrose in Mixed Juice | | | |
|---|---|---|---|---|---|---|---|---|
| | Press Cake | Commercial Sugar | Final Molasses | Undetermined | Press Cake | Commercial Sugar | Final Molasses | Undetermined |
| H. C. & S. Co. | 6.8 | 74.8 | 15.8 | 2.6 | 1.3 | 89.1 | 7.7 | 1.9 |
| Oahu | 2.3 | 79.3 | 16.7 | 1.7 | 0.2 | 91.4 | 7.8 | 0.6 |
| Ewa | 5.1 | 74.7 | 17.5 | 2.7 | 0.2 | 90.0 | 8.0 | 1.8 |
| Pioneer | 3.8 | 78.8 | 15.9 | 1.5 | 0.3 | 93.3 | 6.7 | —0.3 |
| Waialua | 6.9 | 71.0 | 17.8 | 4.3 | 0.5 | 87.3 | 9.1 | 3.1 |
| Maui Agr. | 3.9 | 77.1 | 16.9 | 2.1 | 1.3 | 90.7 | 7.8 | 0.2 |
| Onomea | 5.1 | 78.2 | 15.1 | 1.6 | 0.0 | 92.1 | 6.6 | 1.3 |
| Hakalau | 4.0 | 78.0 | 15.2 | 2.8 | 0.2 | 92.0 | 6.6 | 1.2 |
| Hilo | 5.0 | 76.1 | 13.7 | 5.2 | 0.3 | 90.9 | 6.4 | 2.4 |
| Haw. Agr. | 4.8 | 76.3 | 17.2 | 1.7 | 0.9 | 88.9 | 8.4 | 1.8 |
| Wailuku | 4.9 | 77.5 | 16.8 | 0.8 | 0.2 | 91.5 | 7.9 | 0.4 |
| Makee | 2.3 | 70.7 | 22.0 | 5.0 | 0.4 | 86.3 | 11.0 | 2.3 |
| Laupahoehoe | 3.8 | 77.2 | 16.5 | 2.5 | 0.2 | 89.8 | 8.1 | 1.9 |
| Pepeekeo | 5.0 | 76.9 | 15.1 | 3.0 | 0.2 | 92.0 | 6.3 | 1.5 |
| Waiakea | 4.5 | 75.8 | 14.6 | 5.1 | 0.2 | 89.4 | 7.2 | 3.2 |
| Hamakua | 5.4 | 70.3 | 8.8 | 15.5 | 1.6 | 84.2 | 4.6 | 9.6 |
| Honomu | 5.4 | 77.4 | 15.1 | 2.1 | 0.3 | 92.2 | 6.5 | 1.0 |
| Paauhau | 5.1 | 75.6 | 16.7 | 2.6 | 0.5 | 90.9 | 7.8 | 0.8 |
| Hutchinson | 4.5 | 74.0 | 18.9 | 2.6 | 0.3 | 87.3 | 9.9 | 2.5 |
| Kilauea | 3.8 | 61.0 | 28.2 | 7.0 | 0.7 | 77.6 | 15.2 | 6.5 |
| Kohala | 7.1 | 74.6 | 17.0 | 1.3 | 0.4 | 90.8 | 8.2 | 0.6 |

Data for making up these balances have been reported from the same factories as last year. The writer would again point out the desirability of the remaining factories making the necessary determinations so that this more accurate basis can be used for the control. Improvements in methods resulting in greater simplicity and a reduction in the time required, render it comparatively easy to make the change. Balances calculated on a polarization basis are deceptive, for the undetermined loss so found is smaller than it is in reality. An arithmetical average of the undetermined losses shown by the more accurate true sucrose figures in Table 4 is over 0.6 larger than the arithmetical average of the undetermined losses of the same factories on a polarization basis.

## BOILING HOUSE RECOVERY

Boiling house recoveries based on polarization and the assumptions noted at the foot of the table, compared with the calculated available sugar appear in Table 5. The use of these assumptions introduces a factor of error, probably not over plus or minus 1%. On this basis recoveries of over 101% on the calculated available indicate the probability of errors in the control, while recoveries of under 99% may indicate such errors or actual losses. Recoveries on available higher than 101% are reported from three factories.

Table 6 is a similar comparison of the factories furnishing the necessary data on the more accurate true sucrose basis. In previous synopses the statement has been made that there would seem to be no reason other than errors in the control, why the recoveries on available in this table should exceed 100%. It would seem that such a statement should be modified, particularly as a third of the factories included in Table 6, this year report recoveries of 100% or more. It is well known that the condensate resulting from evaporating and boiling operations is not pure water. In reboiling molasses at this Station, acid products have always been found in the condensate, and during crystallization gases have usually been given off. Also in many factories, where an increased amount of lime has been used in clarification the presence of ammonia in the condensate is quite apparent. We have no definite information as to the extent to which the volatilization of solids, of which the above is evidence, occurs. Presumably it is greater in amount with a more alkaline clarification. Such volatilization of solids in the evaporators does not affect calculations such as those in Table 6, as they are based on syrup purities. Occuring in subsequent operations, however, volatilization of solids would tend to reduce the molasses produced and to increase the sucrose recovery in proportion to the calculated amount.

## CLARIFICATION

For the first time in eight years, with the single exception of in 1918, the increase in purity from mixed juice to syrup has been larger than in the preceding season. The increase, 1.23, is smaller, however, than in any season except 1921. Sixty-two per cent of the factories report larger increases than last year.

## TABLE NO. 5.

## APPARENT BOILING-HOUSE RECOVERY.

Comparing percent available sucrose in the syrup (calculated by formula) with percent polarization actually obtained.

| Factory | Available * | Obtained | Recovery on Available |
|---|---|---|---|
| H. C. & S. Co. | 91.32 | 91.42 | 100.1 |
| Oahu | 91.24 | 92.04 | 100.9 |
| Ewa | 90.98 | 91.17 | 100.2 |
| Pioneer | 92.27 | 93.62 | 101.5 |
| Waialua | 89.38 | 88.23 | 98.7 |
| Maui Agr. | 90.52 | 91.89† | 101.5 |
| Haw. Sug. | 92.37 | 92.36 | 100.0 |
| Olaa | 90.22 | 89.29 | 99.0 |
| Onomea | 93.13 | 92.61 | 99.4 |
| Hakalau | 92.05 | 92.85 | 100.9 |
| Kekaha | 89.76 | 89.10 | 99.3 |
| McBryde | 90.19 | 85.92 | 95.3 |
| Hilo | 91.38 | 91.25 | 99.9 |
| Lihue | 88.64 | 90.09 | 101.6 |
| Haw. Agr. | 91.31 | 89.68 | 98.2 |
| Wailuku | 91.75 | 91.96 | 100.2 |
| Makee | 86.42 | 87.27 | 101.0 |
| Honokaa | 89.87 | 89.02 | 99.1 |
| Laupahoehoe | 91.25 | 90.63 | 99.3 |
| Pepeekeo | 92.73 | 92.57 | 99.8 |
| Waiakea | 90.97 | 90.01 | 98.9 |
| Kahuku | 86.81 | 84.47 | 97.3 |
| Koloa | 85.26 | 84.85 | 99.5 |
| Hamakua | 88.72 | 85.83 | 96.7 |
| Honomu | 92.77 | 93.04 | 100.3 |
| Paauhau | 91.07 | 91.23 | 100.2 |
| Hawi | 91.42 | 84.02 | 91.9 |
| Hutchinson | 89.53 | 88.31 | 98.6 |
| Waianae | 88.78 | 85.89 | 96.7 |
| Kaiwiki | 90.27 | 90.40 | 100.1 |
| Kilauea | 83.65 | 78.21 | 93.5 |
| Kohala | 91.14 | 91.33 | 100.2 |
| Kaeleku | 86.28 | 85.84 | 99.5 |
| Niulii | 89.48 | 89.82 | 100.4 |
| Halawa | 90.49 | 85.75 | 94.8 |
| Waimea | 87.20 | 81.21 | 93.1 |
| Olowalu | 90.35 | 86.45 | 95.7 |
| Union Mill | 89.98 | 88.22 | 98.0 |
| Kipahulu | 88.63 | 86.57 | 97.7 |

* In order to calculate the available sucrose it is necessary to estimate the gravity purity of the syrup and sugar. Data from factories determining both apparent and gravity purities indicate that the average correction necessary is the addition of 0.8 to the apparent purity of the syrup and 0.3 to the apparent purity of the sugar. When the moisture in the sugar has not been reported 1% has been taken. 38 has been used when the gravity purity of the molasses has not been reported.

† Sucrose.

## TABLE NO. 6.

### TRUE BOILING-HOUSE RECOVERY.

Comparing percent sucrose available and recovered.

| Factory | Available | Obtained | % Recovery on Available |
|---|---|---|---|
| H. C. & S. Co. | 91.43 | 90.27 | 98.7 |
| Oahu | 91.30 | 91.58 | 100.3 |
| Ewa | 91.13 | 90.18 | 99.0 |
| Pioneer | 92.07 | 93.58 | 101.6 |
| Waialua | 89.28 | 87.74 | 98.3 |
| Maui Agri | 90.52 | 91.89 | 101.5 |
| Onomea | 93.10 | 92.10 | 98.9 |
| Hakalau | 92.09 | 92.18 | 100.1 |
| Hilo | 91.17 | 91.17 | 100.0 |
| Haw. Agr. | 91.38 | 89.71 | 98.2 |
| Wailuku | 91.82 | 91.68 | 99.9 |
| Makee | 86.33 | 86.65 | 100.4 |
| Laupahoehoe | 91.23 | 89.98 | 98.6 |
| Pepeekeo | 92.61 | 92.18 | 99.5 |
| Waiakea | 90.74 | 89.58 | 98.7 |
| Hamakua | 88.46 | 85.57 | 96.7 |
| Honomu | 92.69 | 92.48 | 99.8 |
| Paauhau | 90.83 | 91.36 | 100.6 |
| Hutchinson | 89.59 | 87.56 | 97.7 |
| Kilauea | 82.96 | 78.15 | 94.2 |
| Kohala | 91.08 | 91.16 | 100.1 |

## TABLE NO. 7.

### PERCENT MOLASSES PRODUCED ON THEORETICAL.

| | | | |
|---|---|---|---|
| H. C. & S. Co. | 88.1 | Honokaa | 95.0 |
| Oahu | 90.3 | Laupahoehoe | 87.4 |
| Ewa | 87.9 | Pepeekeo | 84.4 |
| Pioneer | 91.4 | Waiakea | 74.5 |
| Waialua | 81.0 | Kahuku | 78.0 |
| Maui Agr. | 88.9 | Koloa | 89.6 |
| Haw. Sug. | 82.1 | Hamakua | 36.2 |
| Olaa | 93.7 | Honomu | 89.6 |
| Honolulu | 99.4 | Paauhau | 86.2 |
| Onomea | 90.0 | Hutchinson | 88.6 |
| Hakalau | 84.7 | Kaiwiki | 71.5 |
| Kekaha | 87.7 | Kilauea | 81.0 |
| McBryde | 94.3 | Kohala | 94.2 |
| Hilo | 72.4 | Kaeleku | 82.1 |
| Lihue | 89.6 | Niulii | 95.8 |
| Haw. Agr. | 88.9 | Waimea | 82.9 |
| Wailuku | 95.0 | Olowalu | 91.9 |
| Makee | 81.7 | | |

The amount of lime used has increased from 0.074 to 0.084% on cane. Twenty-three factories report larger and eight smaller amounts. Of the factories using more lime, 75% report a better increase in purity than last season, while 60% of the factories using less lime report smaller increases. Factories that used the same amount of lime as the previous season are evenly divided between larger and smaller increases in purity.

The polarization of the press cake is higher than in any year for which the figures have been averaged. The same is true of the weight of press cake, and also the loss of polarization in press cake per cent polarization of the cane. The latter has now increased to over half of one per cent. The increase in the lime used has contributed to the increased loss in press cake, for with more alkaline clarification it has been necessary to filter a greater volume of settlings, thus increasing the work required of the presses. Without doubt also less water has been used in sweetening off for reasons similar to those that have resulted in the reduction in maceration.

Attention is called to the averages at the bottom of the column headed "Increase in Purity" and "Press Cake—Weight per 100 Cane," in the first of the large tables. With few exceptions the increase in purity has steadily diminished from year to year while an equally consistent increase has taken place in the weight of press cake per cent cane. This increase in the amount of press cake may be accepted as a fairly reliable indication of the increase in the amount of cush cush in the juice, for while definite information as to what proportion of the press cake consists of cush cush is not at present available, it is probable that, depending on the conditions at different factories, it amounts to from 60 to 80% of the solids in the cake. The term "cush cush" is here used to designate particles of sufficient size to be removed by screening. Lime and heat dissolve a part of such material. That the addition of impurities to the juice in this manner actually takes place during clarification has been demonstrated in experimental work at this Station. This, with inferences that might be drawn from the figures referred to above, and detailed analyses of figures from individual factories which point strongly in the same direction, leaves little doubt but that the constantly increasing amount of cush cush in the mixed juice has been an important factor contributing to the smaller increases in purity. There is also little doubt but that the increased amount of press cake this season would have been accompanied by a still smaller "Increase in Purity" had it not been for the use of an increased amount of lime in clarification.

## EVAPORATION

The syrup was evaporated to a higher density than in any previous year; an improvement in the work from the standpoint of fuel economy. Bringing the syrup to a higher density has required less evaporation per cent cane than in previous years, because of a smaller quantity of mixed juice, the result of decreased maceration.

## COMMERCIAL SUGAR

There has been a slight increase in the polarization of the commercial sugar, the figures being 96.75 last year against 96.88 this season. The moisture in the commercial sugar has decreased from 0.92 to 0.87%. The deterioration factor remains unchanged at 0.28, the decrease in moisture being in proportion to the increase in polarization. Experiments have shown that deterioration can take place in Hawaiian sugars with a deterioration factor above 0.25. In sugar of 96.88 polarization, 0.78% moisture corresponds to a deterioration factor of 0.25. A deterioration factor of 0.28 is dangerously near the point where deterioration may be expected.

## FINAL MOLASSES

The gravity purity of the final molasses has increased from 38.53 to 38.75, the latter figure being identical with the 1920 average. Higher syrup purities have had a tendency to decrease the amount of molasses, and notwithstanding the higher molasses purity, the weight of molasses per cent cane, and also the loss of sucrose in molasses per cent cane are considerably smaller than last year. Had the molasses purity been reduced to the point reached last year, the recovery of sugar would have been further increased by almost 0.1.

Table 7 shows the molasses accounted for compared with the theoretical amount. The latter has been assumed to be the solids in the syrup less the solids recovered in the commercial sugar. While calculating the theoretical amount of molasses in this way is not free from objection, it gives a satisfactory comparative figure except when undertermined losses are very large. This is the fourth year that Table 7 has been compiled. The figures reported have been more consistent in each succeeding year. This year but five factories report less than 80% of the theoretical amount against ten last year, and for the first time none of the factories report more than 100%.

Applying similar calculations to the averages we find that in 1921, 87.2% of the theoretical amount of molasses was recovered. In 1922 the figure is slightly lower; 86.3%. The difference is not great, but is in the direction that would be expected if the previously mentioned volatilization of solids, presumably greater in more alkaline liquors, takes place to any material extent.

Twenty-one of the forty-one factories weigh the final molasses. Control figures from the others would be more reliable if actual weights instead of weights calculated from measurements were available, for the latter are at best an approximation. Fortunately nearly all of the larger factories are included in these twenty-one that weigh the molasses, and inaccuracies in the figures from the smaller factories, due to measurements, do not greatly influence the true averages.

## RECOVERY

Compared with the previous season the recovery per cent polarization of the cane has increased from 85.86 to 87.02, a difference of 1.16 and the boiling

house recovery from 88.03 to 89.68, a difference of 1.65. Some 60% of the higher recovery can be credited to higher syrup purities and 40% to reductions in undetermined losses. These higher recoveries, however, have not quite made up for the poorer quality of the cane, and it has required 8.62 tons of cane to make a ton of sugar this year against 8.61 a year ago.

Last year attention was called to figures showing that during the two previous seasons boiling house recoveries compared with the calculated available had been decreasing, larger undetermined losses being the principal cause. These figures, with the corresponding figures for 1922, and also the undetermined losses, appear in the following tabulation. In calculating the available, the average of the differences between apparent and gravity purities reported from the factories where both are determined, have been used. It should be noted that the available does not necessarily represent the maximum possible recovery, as in calculating the available, the gravity purity of the molasses actually secured has been used. For this reason a reduction in final molasses purity would increase the calculated available. Failure of some of the factories to report molasses separately detracts from the accuracy of the figures for undetermined losses. Figures for 1921 and 1922 are not materially affected. In 1920 and particularly in 1919 a larger number of factories failed to report molasses separately and figures for these years are somewhat less accurate. Previous to 1919 the average undetermined loss could not be calculated with any degree of accuracy.

| Year. | Available. | Recovery. | Recovery on Available. | Undetermined Loss. |
|---|---|---|---|---|
| 1919 ............... | 91.87% | 90.96% | 99.01% | 1.27% |
| 1920 ............... | 91.17 | 89.56 | 98.23 | 1.76 |
| 1921 ............... | 89.87 | 88.03 | 97.95 | 1.97 |
| 1922 ............... | 90.57 | 89.68 | 99.02 | 1.27 |

The recovery on available has increased to approximately the value that it was in 1919. As the low grade work, or to be more exact, the purity to which the final molasses is reduced, does not affect the above calculations, it will be noted that the reduction in undetermined loss has been sufficiently large to make up for 0.2 greater loss in press cake and still bring about the improvement in the recovery on available shown above. The results of experimental work at this Station together with observations made at the different factories enable the writer to state that the smaller undetermined loss is principally because the more alkaline clarification has resulted in a reduction in the amount of inversion.

Comparing this year's work with last, factors that have tended to increase the losses are lower extraction, increased loss at the filter presses and slightly higher molasses purity. These less favorable results have been more than offset by a smaller difference in purity between first mill and mixed juices, a better increase in purity during clarification and a large reduction in the undetermined loss. The result has been that though the quality ratio would indicate an increase of .034 in the tons of cane required to make a ton of sugar over that necessary in 1921, the increase has been actually but .01 ton.

Theories are sometimes advanced that high extractions do not improve the total recovery. If such theories are valid it necessarily follows that a decrease in extraction will cause improvements in boiling house work to such an extent that the recovery of sucrose percent sucrose in the cane will not be reduced. Figures in the present synopsis are of particular interest, because as noted above the decrease in extraction has been more than offset by recoveries in the boiling house. The writer has studied the figures in as detailed a manner as available time has permitted to see if evidence could be found to substantiate such theories; that is to see if the improvement in boiling house work can reasonably be credited to lower extraction.

For a reduction in the extraction to bring about better boiling house work it must either cause a reduction in the difference between first mill and mixed juice purities, cause a larger increase in purity during clarification, reduce the loss in press cake, or lower the purity of the final molasses. A decrease of 0.34 has taken place in the difference between first mill and mixed juice purities. If the whole of this difference be considered as an improvement in the purity of the mixed juice due to lower extraction, the extra recovery obtainable on this account would amount to some three-quarters of the extra sugar that could be expected had the extraction been equivalent to that of last year. Figures previously discussed, however, render it extremely doubtful if any considerable part of the reduction in this difference has actually been due to lower extraction. The increase in purity during clarification is larger than last year, but this can hardly be credited to lower extraction. Figures discussed in the paragraph on clarification, together with other available data definitely credit this to the use of more lime in clarification. As both loss in press cake and the final molasses purity are higher than last year these factors need not be further considered in this connection.

The greater part of the improvement in the boiling house work is due to a reduction in the undetermined loss, a factor that does not seem in any way dependent on the quality of the milling work. There is, indeed, ample evidence to substantiate the view that this reduction in the undetermined loss is also for the greater part due to the use of more lime in clarification. Further analyses of the figures might throw more light on the subject, but these can not now be made on account of the limited time available for the preparation of this Synopsis. Such examination as has been made, however, indicates that improved work in the boiling house can be credited to lower extraction only to the extent that the latter may have contributed to the reduction in the difference between first mill and mixed juice purities, the major part of the improvement being more or less directly attributable to better conducted clarification.

## FACTORY EFFICIENCY

Table 8 has again been included as the writer considers that such comparisons with standards of work somewhat better than that attained at any of the factories are of value. As some objections to the use of these data as means of comparing the efficiencies of the different factories have been pointed out, the title of the table has been changed from Factory Efficiency to Comparison of Actual and Calculated Recoveries.

The calculations in this Synopsis have been made by A. Brodie assisted by H. A. Cook.

## TABLE NO. 8.

### COMPARISON OF ACTUAL AND CALCULATED RECOVERIES.

The factories are arranged in the order of the ratio of their recovery to that resulting from 100% extraction, reducing the molasses to 30 gravity purity, and eliminating all other losses. Factories reporting a recovery of over 101% of the available (Table No. 5) are omitted from this tabulation.

| No. | Factory | Milling | Boiling House | Over All |
|---|---|---|---|---|
| 1 | Hakalau | 98.84 | 98.59 | 97.55 |
| 2 | Onomea | 98.79 | 97.64 | 96.61 |
| 3 | Pepeekeo | 98.00 | 98.31 | 96.44 |
| 4 | Honomu | 97.34 | 98.27 | 95.84 |
| 5 | Hilo | 98.48 | 96.75 | 95.38 |
| 6 | Haw. Sug. | 97.82 | 97.29 | 95.32 |
| 7 | Wailuku | 97.69 | 97.18 | 95.19 |
| 8 | Paauhau | 97.30 | 96.92 | 94.55 |
| 9 | Oahu | 96.73 | 97.34 | 94.45 |
| 10 | H. C. & S. Co. | 98.19 | 95.51 | 94.01 |
| 11 | Ewa | 96.19 | 97.33 | 93.93 |
| 12 | Kohala | 95.72 | 96.67 | 92.74 |
| 13 | Makee | 97.06 | 95.17 | 92.68 |
| 14 | Laupahoehoe | 96.66 | 95.54 | 92.56 |
| 15 | Kaiwiki | 95.34 | 96.06 | 91.91 |
| 16 | Kekaha | 96.59 | 94.94 | 91.86 |
| 17 | Olaa | 96.26 | 94.88 | 91.76 |
| 18 | Honokaa | 96.27 | 94.81 | 91.53 |
| 19 | Waialua | 96.97 | 93.91 | 91.30 |
| 20 | Olowalu | 97.53 | 93.30 | 91.21 |
| 21 | Haw. Agr. | 97.06 | 93.81 | 91.20 |
| 22 | Koloa | 97.09 | 93.19 | 90.84 |
| 23 | Waiakea | 95.18 | 95.07 | 90.80 |
| 24 | Hutchinson | 95.72 | 93.46 | 89.76 |
| 25 | Kaeleku | 95.06 | 93.59 | 89.21 |
| 26 | McBryde | 96.43 | 92.10 | 89.07 |
| 27 | Waianae | 96.07 | 92.39 | 89.06 |
| 28 | Kahuku | 94.95 | 93.12 | 88.81 |
| 29 | Niulii | 91.40 | 95.32 | 87.39 |
| 30 | Union Mill | 93.84 | 92.73 | 87.32 |
| 31 | Hawi | 96.79 | 88.93 | 86.24 |
| 32 | Hamakua | 95.15 | 90.39 | 86.20 |
| 33 | Waimea | 97.45 | 87.10 | 85.00 |
| 34 | Halawa | 93.48 | 90.67 | 84.95 |
| 35 | Kipahulu | 90.35 | 92.24 | 83.68 |
| 36 | Kilauea | 96.70 | 86.17 | 83.59 |

## TABLE NO. 9.

## SUMMARY OF LOSSES.

| FACTORY | POUNDS POLARIZATION PER TON OF CANE | | | | | | POLARIZATION PER 100 CANE | | | | | | POLARIZATION PER 100 POLARIZATION OF CANE | | | | | | Syrup Purity | FACTORY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bagasse | Press Cake | Molasses | Other Known | Undetermined | TOTAL | Bagasse | Press Cake | Molasses | Other Known | Undetermined | TOTAL | Bagasse | Press Cake | Molasses | Other Known | Undetermined | TOTAL | | |
| H. C. & S. Co. | 5.4 | 3.8 | 22.6 | ... | 2.0 | 33.8 | 0.27 | 0.19 | 1.13 | ... | 0.10 | 1.69 | 1.81 | 1.31 | 7.64 | ... | 0.67 | 11.43 | 86.32 | H. C. & S. Co. |
| Oahu | 9.4 | 0.6 | 21.6 | ... | 0.2 | 31.8 | 0.47 | 0.03 | 1.08 | ... | 0.01 | 1.59 | 3.27 | 0.19 | 7.60 | ... | 0.08 | 11.14 | 86.44 | Oahu |
| Ewa | 10.2 | 0.6 | 20.8 | ... | 1.8 | 33.4 | 0.51 | 0.03 | 1.04 | ... | 0.09 | 1.67 | 3.81 | 0.21 | 7.81 | ... | 0.66 | 12.49 | 84.58 | Ewa |
| Pioneer | 6.2 | 1.0 | 18.6 | 0.2 | —1.4 | 24.6* | 0.31 | 0.05 | 0.93 | 0.01 | —0.07 | 1.23* | 2.21 | 0.33 | 6.62 | 0.07 | —0.47 | 8.76* | 85.49 | Pioneer |
| Waialua | 8.4 | 1.4 | 24.6 | ... | 6.6 | 40.1 | 0.42 | 0.07 | 1.23 | ... | 0.33 | 2.05 | 3.03 | 0.47 | 8.95 | ... | 2.41 | 14.86 | 84.6 | Waialua |
| Maui Agr. | 8.2 | 3.4 | 20.6 | ... | 0.4 | 32.6*† | 0.41 | 0.17 | 1.03 | ... | 0.02 | 1.63*† | 3.01 | 1.25 | 7.60 | ... | 0.17 | 12.03*† | 85 34 | Maui Agr. |
| Haw. Sug. | 6.6 | 2.0 | 18.8 | ... | 3.4 | 30.8 | 0.33 | 0.10 | 0.94 | ... | 0.17 | 1.54 | 2.18 | 0.65 | 6.31 | ... | 1.12 | 10.26 | 85.82 | Haw. Sug. |
| Olaa | 9.0 | 1.2 | 22.2 | ... | 2.2 | 34.6 | 0.45 | 0.06 | 1.11 | ... | 0.11 | 1.73 | 3.74 | 0.48 | 9.29 | ... | 0.96 | 14.47 | 85.0 | Olaa |
| Honolulu | 9.8 | 0.4 | 32.0 | 0.8 | ... | ... | 0.49 | 0.02 | 1.60 | 0.04 | ... | ... | 3.49 | 0.14 | 11.49 | 0.30 | ... | .... | 85.52 | Honolulu |
| Onomea | 3.0 | 0.2 | 16.0 | ... | 1.8 | 21.0 | 0.15 | 0.01 | 0.80 | ... | 0.09 | 1.05 | 1.21 | 0.05 | 6.53 | ... | 0.77 | 8.56 | 87.05 | Onomea |
| Hakalau | 2.8 | 0.4 | 16.2 | ... | 1.0 | 20.4 | 0.14 | 0.02 | 0.81 | ... | 0.05 | 1.02 | 1.16 | 0.16 | 6.62 | ... | 0.44 | 8.38 | 85.33 | Hakalau |
| Kekaha | 9.4 | 1.6 | 24.8 | ... | 4.0 | 39.8 | 0.47 | 0.08 | 1.24 | ... | 0.20 | 1.99 | 3.41 | 0.62 | 9.01 | ... | 1.45 | 14.49 | 84.19 | Kekaha |
| McBryde | 9.6 | 0.6 | 28.8 | ... | 7.6 | 46.6 | 0.48 | 0.03 | 1.44 | ... | 0.38 | 2.33 | 3.57 | 0.23 | 10.71 | ... | 2.83 | 17.34 | 83.74 | McBryde |
| Hilo | 3.6 | 0.6 | 14.6 | ... | 5.4 | 24.2 | 0.18 | 0.03 | 0.73 | ... | 0.27 | 1.21 | 1.52 | 0.24 | 6.32 | ... | 2.28 | 10.36 | 85.54 | Hilo |
| Lihue | 6.8 | 1.0 | 23.2 | ... | 0.0 | 31.0* | 0.34 | 0.05 | 1.16 | ... | 0.00 | 1.55* | 2.80 | 0.43 | 9.58 | ... | 0.01 | 12.82* | 81.60 | Lihue |
| Haw. Agr. | 7.0 | 2.0 | 19.6 | ... | 4.2 | 32.8 | 0.35 | 0.10 | 0.98 | ... | 0.21 | 1.64 | 2.94 | 0.88 | 8.20 | ... | 1.72 | 13.74 | 86.79 | Haw. Agr. |
| Wailuku | 6.2 | 0.4 | 20.4 | ... | 0.2 | 27.2 | 0.31 | 0.02 | 1.02 | ... | 0.01 | 1.36 | 2.31 | 0.18 | 7.74 | ... | 0.10 | 10.33 | 86.3 | Wailuku |
| Makee | 6.8 | 1.0 | 25.2 | ... | 3.6 | 36.6 | 0.34 | 0.05 | 1.26 | ... | 0.18 | 1.83 | 2.94 | 0.39 | 10.75 | ... | 1.55 | 15.63 | 81.35 | Makee |
| Honokaa | 8.6 | 1.0 | 22.6 | ... | 1.6 | 33.8 | 0.43 | 0.05 | 1.13 | ... | 0.08 | 1.69 | 3.73 | 0.45 | 9.84 | ... | 0.68 | 14.70 | 84.44 | Honokaa |
| Laupahoehoe | 8.2 | 0.4 | 19.4 | ... | 2.8 | 30.8 | 0.41 | 0.02 | 0.97 | ... | 0.14 | 1.54 | 3 34 | 0.18 | 7.88 | ... | 1.16 | 12.56 | 86.71 | Laupahoehoe |
| Pepeekeo | 4.6 | 0.6 | 14.4 | ... | 2.6 | 22.2 | 0.23 | 0.03 | 0.72 | ... | 0.13 | 1.11 | 2.00 | 0.22 | 6.19 | ... | 1.07 | 9.48 | 85.38 | Pepeekeo |
| Waiakea | 12.0 | 0.6 | 17.2 | ... | 6.4 | 36.2 | 0.60 | 0.03 | 0.86 | ... | 0.32 | 1.81 | 4.82 | 0.24 | 6.89 | ... | 2.60 | 14.55 | 86.23 | Waiakea |
| Kahuku | 11.8 | 1.4 | 25.0 | ... | 9.6 | 47.8 | 0.59 | 0.07 | 1.25 | ... | 0.48 | 2.39 | 5.05 | 0.61 | 10.60 | ... | 4.05 | 20.31 | 79.18 | Kahuku |
| Koloa | 7.0 | 1.8 | 32.0 | ... | 3.4 | 44.2 | 0.35 | 0.09 | 1.60 | ... | 0.17 | 2.21 | 2.91 | 0.76 | 13.21 | ... | 1.38 | 18.26 | 79.6 | Koloa |
| Hamakua | 12.4 | 4.0 | 11.2 | ... | 22.8 | 50.4 | 0.62 | 0.20 | 0.56 | ... | 1.14 | 2.52 | 4.85 | 1.54 | 4.36 | ... | 8.91 | 19.66 | 84.5 | Hamakua |
| Honomu | 6.6 | 0.8 | 15.6 | ... | 1.0 | 24.0 | 0.33 | 0.04 | 0.78 | ... | 0.05 | 1.20 | 2.66 | 0.34 | 6.35 | ... | 0.40 | 9.75 | 86.0 | Honomu |
| Paauhau | 6.4 | 1.0 | 18.2 | ... | 2.2 | 27.8 | 0.32 | 0.05 | 0.91 | ... | 0.11 | 1.39 | 2.70 | 0.45 | 7.58 | ... | 0.91 | 11.64 | 84.6 | Paauhau |
| Hawi | 8.6 | 1.2 | ... | ... | 41.4 | 51.2 | 0.43 | 0.06 | ... | ... | 2.07 | 2.56 | 3.21 | 0.46 | ... | ... | 15.40 | 19.07 | 85.3 | Hawi |
| Hutchinson | 9.6 | 0.6 | 21.6 | ... | 3.4 | 35.2 | 0.48 | 0.03 | 1.08 | ... | 0.17 | 1.76 | 4.28 | 0.30 | 9.60 | ... | 1.55 | 15.73 | 85.54 | Hutchinson |
| Waianae | 10.6 | 1.0 | ... | ... | 36.8 | 48.4 | 0.53 | 0.05 | ... | ... | 1.84 | 2.42 | 3.93 | 0.37 | ... | ... | 13.50 | 17.80 | 82.93 | Waianae |
| Kaiwiki | 11.6 | 0.4 | 17.0 | ... | 5.8 | 34.8 | 0.58 | 0.02 | 0.85 | ... | 0.29 | 1.74 | 4.66 | 0.20 | 6.81 | ... | 2.32 | 13 99 | 85.40 | Kaiwiki |
| Kilauea | 7.2 | 1.4 | 32.2 | ... | 13.6 | 54.4 | 0.36 | 0.07 | 1.61 | ... | 0.68 | 2.72 | 3.29 | 0.66 | 14.75 | ... | 6.18 | 24.88 | 79.2 | Kilauea |
| Kohala | 10.8 | 1.0 | 20.2 | ... | 0.8 | 32.8 | 0.54 | 0.05 | 1.01 | ... | 0.04 | 1.64 | 4.28 | 0.42 | 7.92 | ... | 0.34 | 12.96 | 85.4 | Kohala |
| Kaeleku | 11.0 | 1.0 | 24.6 | ... | 5.2 | 41.8 | 0.55 | 0.05 | 1.23 | ... | 0.26 | 2.09 | 4.94 | 0.46 | 11.09 | ... | 2.31 | 18.80 | 81.28 | Kaeleku |
| Waimanalo | ... | 1.0 | ... | ... | ... | ... | ... | 0.05 | ... | ... | ... | ... | ... | ... | ... | ... | ... | .... | .... | Waimanalo |
| Niulii | 21.0 | 0.8 | 22.8 | ... | 0.0 | 44.6 | 1.05 | 0.04 | 1.14 | ... | 0.00 | 2.23 | 8.60 | 0.32 | 9.26 | ... | 0.01 | 18.19 | 85.30 | Niulii |
| Halawa | 14.8 | 2.6 | ... | ... | 29.6 | 47.0 | 0.74 | 0.13 | ... | ... | 1.48 | 2.35 | 6.52 | 1.17 | ... | ... | 13.15 | 20.84 | 84.06 | Halawa |
| Waimea | 7.2 | 1.2 | 35.4 | ... | 15.8 | 59.6 | 0.36 | 0.06 | 1.77 | ... | 0.79 | 2.98 | 2.55 | 0.40 | 12.64 | ... | 5.60 | 21.19 | 83.09 | Waimea |
| Olowalu | 6.6 | 0.6 | 26.4 | ... | 8.2 | 41.8 | 0.33 | 0.03 | 1.32 | ... | 0.41 | 2.09 | 2.47 | 0.24 | 10.06 | ... | 3.12 | 15.89 | 82.6 | Olowalu |
| Union Mill | 15.0 | 5.0 | ... | ... | 26.2 | 46.2 | 0.75 | 0.25 | ... | ... | 1.31 | 2.31 | 6.16 | 2.08 | ... | ... | 10.82 | 19.06 | 83.4 | Union Mill |
| Kipahulu | 23.0 | 4.0 | ... | ... | 28.2 | 55.2 | 1.15 | 0.20 | ... | ... | 1.41 | 2.76 | 9 65 | 1.72 | ... | ... | 11.90 | 23.27 | 82.56 | Kipahulu |

* A comparison of the available sucrose in the juice with the amount recovered in the boiling-house indicates that there is probably an error in some of the results reported from this factory.

† Sucrose.

# Sugar Prices.

## 95° Centrifugals for the Period

## September 16 to December 15, 1922.

| Date | Per Pound | Per Ton | Remarks |
|---|---|---|---|
| Sept. 16, 1922... | 4.73 ¢ | $ 94.60 | Cubas. |
| " 19 ........ | 4.61 | 92.20 | Spot Cubas. |
| " 23 ........ | 4.77 | 95.40 | Spot Cubas. |
| " 28 ........ | 4.885 | 97.70 | Cubas 4.87 and 4.90. |
| " 29 ........ | 4.96 | 99.20 | Cubas. |
| Oct. 2 ........ | 5.0633 | 101.26 | Spot Cubas 5.08, Philippines 5.09, Cubas 5.09 and 5.02. |
| " 3 ........ | 5.28 | 105.60 | Spot Cubas. |
| " 9 ........ | 5.265 | 105.30 | Spot Cubas 5.25, Cubas 5.28. |
| " 10 ........ | 5.31 | 106.20 | Cubas 5.28, Spot Cubas 5.34. |
| " 11 ........ | 5.40 | 108.00 | Cubas. |
| " 13 ........ | 5.525 | 110.50 | Spot Cubas 5.52 and 5.53. |
| " 14 ........ | 5.53 | 110.60 | Spot Cubas. |
| " 27 ........ | 5.59 | 111.80 | Cubas 5.53, Spot Cubas 5.65. |
| " 30 ........ | 5.53 | 110.60 | Cubas. |
| Nov. 17 ........ | 5.59 | 111.80 | Cubas 5.53, Philippines 5.65. |
| " 20 ........ | 5.65 | 113.00 | Cubas. |
| " 25 ........ | 5.78 | 115.60 | Cubas. |
| Dec. 15 ........ | 5.53 | 110.60 | Cubas. |